for Dr Hegr

Toronto
Area
Watershed
Management
Strategy

HUMBER RIVER WATER QUALITY MANAGEMENT PLAN 1986

Ontario

TORONTO AREA WATERSHED MANAGEMENT STRATEGY STEERING COMMITTEE MEMBER AGENCIES

Ontario Ministry of the Environment

Metropolitan Toronto and Region Conservation Authority

Municipality of Metropolitan Toronto

Borough of East York

City of Etobicoke

City of North York

City of Scarborough

City of Toronto

City of York

Regional Municipality of Peel

Regional Municipality of York

Environment Canada

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Acknowledgements

The Toronto Area Watershed Management Strategy (TAWMS) Steering Committee would like to thank the members of the TAWMS Technical Committee, Ministry of the Environment project staff, Metropolitan Toronto and Region Conservation Authority project staff, and the numerous consultants involved in the study, for their efforts and contributions in the preparation of this report and all associated technical reports.

FOREWORD

In 1981 the Ontario Ministry of the Environment (MOE) initiated a study of water quality in the Don River, Humber River and Mimico Creek to provide baseline data to guide future studies. Subsequently, the Toronto Area Watershed Management Strategy Study (TAWMS) was formally organized.

Although wholly funded and managed by MOE, TAWMS receives extensive co-operation and support from the Metropolitan Toronto and Region Conservation Authority (MTRCA) and from the boroughs and cities of the Municipality of Metropolitan Toronto. This multiagency approach is vital to the success of the project and to the implementation of study recommendations.

Initial emphasis was placed on studies of the Humber River watershed during 1982 to 1985. The Don River would be studied from 1984 to 1987, and Mimico Creek was studied in 1982 and 1983.

The areas draining directly to the waterfront were not initially studied in detail; however, with the closure of beaches in the summer of 1983, activities on the lakefront were intensified. These studies are expected to be completed in 1986.

Because of the complexity and great significance of urban water quality problems and because of funding restraints, the intensive study of the Humber River in 1982-83 was limited to the portion of the watershed within the boundaries of Metropolitan Toronto. In 1983 the resolution of water quality problems along the Metropolitan Toronto waterfront was added to the terms of reference for the TAWMS study. In addition, in 1984, a water quality study in the Upper Humber watershed was undertaken.

The TAWMS study is managed by a Steering Committee which includes representatives of the following agencies:

The Ontario Ministry of the Environment
Metropolitan Toronto
Borough of East York
City of Etobicoke
City of North York
City of Scarborough
City of Toronto
City of York
Regional Municipality of Peel
Regional Municipality of York
Metropolitan Toronto and Region Conservation Authority
Environment Canada

1. EXECUTIVE SUMMARY

Introduction

In 1981 the Toronto Area Watershed Management Strategy (TAWMS) Study was initiated to produce a water quality management plan for the Toronto area. The objectives were:

- o To better define water quality conditions within the study area.
- o To analyse the cause and effect relationships for problem constituents and areas.
- o To develop cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and uses.

The main focus to date has been on the Humber River watershed, with particular emphasis on the urban areas within Metropolitan Toronto.

The activities initiated to respond to these objectives included: separate studies of the upper and lower Humber River water quality during dry weather and storm runoff, a special bacteriological study, and a study of the physical characteristics and sediment transport patterns of the river. Urban pollution sources were assessed through studies of pollutant accumulation and washoff and dry weather contaminant loadings for two small drainage systems. The combined sewer system, a source of both stormwater pollutants and sanitary wastes, was monitored and the frequency of Combined Sewer Overflows (CSO) was evaluated by computer simulation. Structural and non-structural pollution control options were evaluated in terms of effectiveness, cost and feasibility. The results of all studies were integrated to predict the effects of control actions on the quality of the Humber River.

Principal Findings

Study results indicate that bacteria, and heavy metals, principally lead, zinc, copper and cadmium, are of primary concern. In addition, contaminants from industrial and residential uses impact the river. Bacteria and heavy metals exceed the Provincial Water Quality Objectives (PWQO) at the Metro Toronto boundary, indicating the need for pollution control efforts in the upper basin. The urban basin is, however, the predominant source of both dry and wet weather contamination.

During dry weather, a limited number of storm sewers contribute bacteria and excessive levels of heavy metals, because of illegal sanitary connections and industrial inputs. During wet weather, combined sewer overflows and stormwater discharge contribute severe loadings of both metals and bacteria. Inappropriate disposal of household hazardous contaminants and industrial residues to the storm sewer system results in intermittent contamination.

Justification for a Control Program

Major improvements can be made in the quality of the Humber River through a combined program of urban and rural pollution control. Substantial reductions in peak concentrations and the duration of PWQO exceedences are achievable if the cost-effective control options are implemented in sufficient degree. Limitations in technology, the number of sites available for structural controls, and high background levels of some metals such as copper, will prevent a complete cleanup of the Humber River. Violations of the PWQO for metals and bacteria will continue to occur, especially during wet weather, although the severity of violation and hence the stresses and risks will be reduced.

The benefits of water quality improvement, where the PWQO is not achieved in all instances, must be examined from the perspective of the uses made of the river. In the Humber River, the primary uses relate to public health (impacts on swimming, wading) and fisheries. Use made of the Western Beaches also produces public health concerns for the water quality of the river. In terms of

public health the objective is to reduce the levels of fecal coliform (FC) bacteria to 100 organisms/100 ml. FC bacteria are not hazardous in themselves but rather are indicators of fecal contamination and the potential presence of disease causing pathogens. The dry weather control options available, together with depletion by natural processes, will allow reduction of FC levels to below the stated objective near the mouth of the Humber, under the dry weather conditions which prevail about 85% of the time during the summer. Similar improvements in the upper reaches of the river will be dependent upon the success of programs in the rural basin.

Public health concerns during wet weather can be decreased through reduction of CSO and augmented programs of dog litter control. The public health implications of CSO reduction are very important because the overflows contain human fecal matter which potentially harbour specific human pathogens. Previous studies have suggested that dog control programs may reduce FC bacteria loads by up to 20%.

Despite efforts in reducing CSO and dog litter, the PWQO for FC bacteria will continue to be exceeded during wet weather. In terms of public health it will likely be necessary to continue to prohibit body contact with the river following rainfall periods, even though the control efforts are likely to reduce the potential risk to the public. A similar comment applies to the Western Beaches although the Humber River is only one of several sources of fecal contamination along the waterfront.

Fishing in the Humber River is in great demand as evidenced by the number of anglers and the current stocking programs to meet the demand. Heavy metal concentrations in the Humber River exceed the PWQO regularly, and are highest during wet weather. Fish exist in most of the river, however, and fisheries concerns relate primarily to the sublethal effects of heavy metals and sediment, which may impact on spawning, longevity and bioaccumulation. There is evidence that fish are currently under stress and it is expected that the reductions in sediment and heavy metal concentrations possible will result in a significant enhancement of the capability of the river to support desirable fish species. This expectation will have to be confirmed with a fisheries enhancement program.

The options available for reducing sediment and heavy metal input to the river include sediment and erosion control, more frequent catchbasin cleaning and stormwater retention ponds. Each of these options is cost-effective. The first two options can be implemented easily through continuation and expansion of existing programs. Stormwater retention ponds, which show the greatest potential for heavy metal control, may conflict with existing land uses such as park or open space areas. Reduction of sediment and heavy metal concentrations can be begun by using the first two options. The capability of retention ponds to improve fishery potential should be evaluated further through pilot scale test projects in conjunction with habitat improvement programs. This evaluation is necessary to establish the viability of fisheries enhancement so that adequate information is available to allow resolution of land use conflicts.

The Water Quality Management Plan

Rehabilitation of the Humber River requires a continuing long term effort on the part of the province, municipalities, industry and the public. Many control options are either in place or can be initiated immediately. Certain options should be completed in phases, with the initial effort directed toward pilot scale testing and evaluation of benefits over a period of about 5 years, followed by larger scale implementation of proven options in the second phase.

Phase 1

Programs which are underway and which should be continued include:

- reduction of dry weather sources of bacteria through tracing and disconnecting illegal sanitary connections in known priority sewers.

- reduction of dry weather sources of chemical contamination from known priority sewers through continued plumbing inspections.

- reduction of sediment delivery to the river through existing programs of sediment and erosion control and stormwater management.

- inspection and monitoring of snow disposal sites to ensure that they meet MOE guidelines.

- encourage senior levels of government to seek reductions in air emissions in order to reduce deposition of contaminants on the watershed.

These existing programs should be immediately supplemented by the non-structural measures listed below. The frameworks for these programs are in place. Modifications to existing bylaws and the commitment of additional staff will be required. The cost of these non-structural measures will be program-dependent.

- reduce dry weather chemical contamination by modifying existing sewer use bylaws and increasing inspection and enforcement.

- reduce illicit dumping and improper handling of industrial wastes through industrial inventories and education, and increased inspection and monitoring.

- reduce contamination by household hazardous contaminants through municipally administered education and collection programs.

- evaluate the feasibility of collecting dry weather discharge from priority sewers where the tracing program has achieved limited success.

- augment enforcement of existing dog and litter control bylaws.

- implement agricultural controls to: limit livestock access to streams; reduce soil, nutrient and pesticide loss; prevent contamination from manure storage areas.

- expand programs to mitigate diffuse urban sources of contamination on the upper watershed, such as: determine whether upgrading of the Kleinburg sewage treatment plant is warranted; continue to trace and test old landfills; trace and disconnect illegal sanitary and agricultural waste connections to field tile drains; inspect and mitigate poorly designed or operated septic systems.

In addition to the non-structural measures listed above, the following operational and structural measures should be immediately implemented:

- the frequency of catchbasin cleaning should be increased to twice yearly in all areas.
  Estimated present value cost: \$3.7 million

- the existing program of sewer separation in the City of York should be replaced with a program to install local detention tanks (to reduce basement flooding) and combined sewer overflow tanks (to reduce CSO to approximately 1/year). Studies should be conducted in other municipalities to determine the utility of alternatives to sewer separation.
  Estimated present value cost: \$19 million
  Estimated present value saving: \$65.7 million

The Phase 1 program should be supplemented by several pilot scale projects, as below:

- construction of a stormwater retention pond on Emery Creek near the confluence with the Humber River.
  Estimated present value cost: \$1.3 million

- installation of an ultraviolet disinfection unit in the Emery Creek pond to allow disinfection of dry weather flow

and experimental disinfection of retained stormwater.
Estimated present value cost: $0.2 million

- implementation of pilot scale fishery habitat improvement.
  Not costed.

- construction of pilot scale stormwater retention ponds in new developments on the upper Humber.
  Estimated Cost: program dependent

The phase 1 program will be complemented by an expanded water quality monitoring program, oriented towards evaluation of the improvements made through the phase 1 initiatives. The monitoring results will provide the information necessary to determine the scale of phase 2 initiatives.

Phase 2

Phase 2 programs will only be undertaken if the results of phase 1 demonstrate clear benefits. The proposed phase 2 program could include:

- construction of stormwater retention ponds to control runoff quality from existing industrial areas.
  Estimated present value cost: $3.8 million

- construction of stormwater retention ponds to control runoff quality from existing residential areas.
  Estimated present value cost: $16.2 million

- construction of stormwater retention ponds to control runoff quality from all new developments.
  Not costed.

- construction of ultraviolet disinfection units at selected locations to allow treatment of dry weather flow and/or retained stormwater.
  Not costed.

Two points should be noted in regard to the cost estimates provided. The costs include both capital and annual operating expenses but exclude the cost of land. Land values were collected but were not included in the estimates because the facilities proposed would be constructed on public land. Secondly, the proposed method for reduction of combined sewer overflows will result in a saving of over $65 million compared to the existing program of sewer separation, while allowing more immediate relief of both water quality and basement flooding concerns.

Implementation Considerations

Numerous funding sources and approval mechanisms currently exist which will have an impact on the implementation of the recommendations presented above.

Several of the recommendations involve an enhancement of existing programs, and as such have some form of funding in place. The implementation will thus require, an internal budgetary approval for municipal funds (eg. enhanced catchbasin cleaning), or, changes at the provincial level (eg. the enhanced Ontario Soil Conservation and Environmental Protection Assistance Program, modification of the program for combined sewer separation). Funding for new programs will require the participation of all levels of government.

Most projects would be subject to some approval mechanism. Sewage works are currently subject to approval under the Ontario Water Resources Act. Construction of ponds and other structures in the floodplain would be subject to approval of the Ministry of Natural Resources under the Lakes and Rivers Improvement Act, and Construction and Fill Regulations under the Conservation Authorities Act. Several of the proposals may also be subject to Environmental Assessment.

Based on the analysis of implementation considerations, it is recommended that a committee be established to co-ordinate the

activities of the exsiting agencies in implementing the water quality management plan. The committee would deal with the scheduling and implementation of recommended control options, modify recommendations as required, and make recommendations regarding the implementation of phase 2. The committee would report on progress to the Minister of the Environment, the Chairman of Metropolitan Toronto, the Mayors of the the local municipalities and the Chairman of the Metropolitan Toronto and Region Conservation Authority.

2. INTRODUCTION

Studies by the Ministry of the Environment (MOE) in the late 1970's indicated that the near-shore areas of Lake Ontario in the greater Metropolitan Toronto area were being severely affected by human activities in the tributary watersheds.

In 1981 the MOE initiated a study of water quality in the Don River, Humber River and Mimico Creek to provide baseline data to guide future studies. Use was made of information from a limited sampling program undertaken by TAWMS in 1981 to supplement the historical data base. The results of this first year's problem definition study show that the water courses draining these watersheds have impaired water quality, likely caused by existing land use activities and related drainage discharges. The contributors to the impairement were thought to include municipal, urban and agricultural sources. Water, sediment and biological tissues of freshwater clams and juvenile fish were collected and analysed for nutrients, metals and trace contaminants (MOE, 1983). Routine water quality monitoring data were also reviewed for bacteriological quality. These data indicated impairment as defined by numerous violations of Provincial Water Quality Objectives (PWQO) (MOE, 1984) in the urbanized portions of the Don River, Humber River and Mimico Creek.

The TAWMS study's overall goal is to develop a comprehensive water quality management plan for the study area that would maintain or upgrade water quality in urbanizing and existing urban areas to make these waters more suitable for aquatic life and other beneficial uses. To fullfil this goal, three specific objectives have been defined. They are:

- To better define water quality conditions within the study area.

- To analyse the cause and effect relationships for problem constituents and areas.

- o To develop cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and uses.

Since the greatest water quality impairment was noted in the urban areas that receive discharges from storm and combined sewers and other sources, the major emphasis of the 1982 TAWMS program was on the urban Humber River watershed with limited effort in the Don River and Mimico Creek watersheds. Resources were not available to permit simultaneous detailed analysis for all three watersheds. Detailed work is planned, however, for the remaining watersheds as TAWMS progresses.

As a result of the 82-83 program on the urban Humber River, water quality impairment north of the Metropolitan Toronto boundary was identified and its study was considered important for the development of a management plan. Accordingly, in 1984, the Metropoliatan Toronto and Region Conservation Authority (MTRCA) submitted a proposal to the MOE and received a grant to undertake a water quality study in the Upper Humber watershed. The results and conclusions from the study have been incorporated in this report.

Water quality data from the Don and Humber Rivers and Mimico Creek demonstrate that the urbanized portions of these watersheds exhibit the poorest water quality. This indentification of the urbanized portion of the watersheds as being generally polluted has aroused public concern over the pollution and generated initiatives to begin cleaning up these waterhseds. The International Joint Commision (IJC) has identified the Metropolitan Toronto waterfront as an area of concern (IJC, 1985). In the past, the York-Durham scheme was initiated to divert municipal discharges from the watersheds. In addition, the general public accepted the need to prevent the discharge of sanitary sewage to the watercourses through combined sewerage systems.

A variety of studies were undertaken in the Humber watershed to yield the information needed to achieve the TAWMS study objectives.

As shown in Figure 2.1, background studies fell into two principal categories: water quality activities and pollution control activities.

Water quality activities consisted of studies of water quality in the Humber River itself. These included separate studies of upper and lower Humber River water quality during dry weather and storm runoff, a special bacteriological study, and a study of the physical characteristics and sediment transport patterns of the river. Results of these investigations were employed during preparation of a mathematicl model of the hydrology and water quality for the Humber River.

Pollution control activities consisted of studies of pollutant sources in the urbanized protion of the Humber watershed. Dry weather contaminant loadings were determined for sewer outfalls and for two pilot catchments, one industrial and the other a mixed residential commercial catchment. For these same two catchments, pollutant accumulation and washoff behaviour was determined for selected pollutants. The combined sewer system was monitored and the frequency of combined sewer overflows was evaluated by computer simulation. Results of these studies contributed to the development of the Humber River system model, which was used to evaluate the effects of a variety of control options on Humber River water quality.

This report serves to summarize the findings presented in the detailed technical reports of the above studies. The goal is to provide the background information needed to evaluate alternatives in the preparation of management plans for the Humber watershed. Chapter 3 gives a description of general basin characteristics. Evaluation criteria and procedures are presented in Chapter 4. Chapter 5 summarizes the results of the water quality activities, and Chapter 6 summarizes the results of the pollution control activities. Chapter 7 is a discussion of control options which

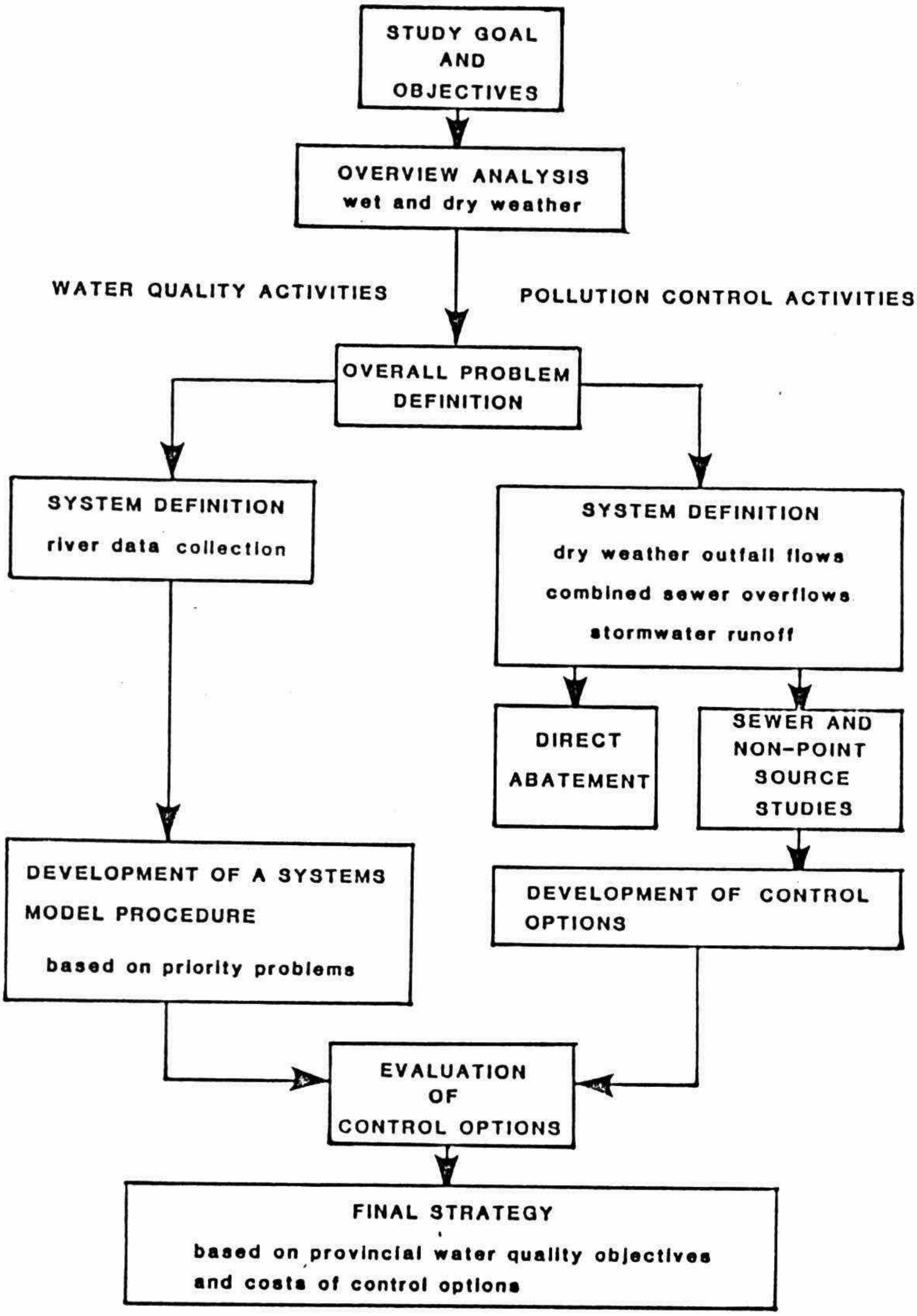

FIGURE 2.1 : DEVELOPMENT OF A WATER QUALITY MANAGEMENT STRATEGY FOR THE HUMBER RIVER

leads into Chapter 8, the presentation of detailed evaluation results. Chapter 9 presents the management plan. Chapter 10 concludes the report by examining implementation considerations.

3. BASIN DESCRIPTION

3.1 LOCATION

The Humber River drainage area of 897 km^2 is the largest watershed under the jurisdiction of the MTRCA. The watershed drains in a south to south-easterly direction to Lake Ontario with its northern boundary being the Lake Ontario - Georgian Bay drainage divide, formed primarily by the Oak Ridges terminal moraine (Figure 3.1). Located within the Regional Municipalities of Peel, York and Metropolitan Toronto, parts of the watershed lie within the individual municipalities of Caledon, Brampton, Mississauga, King, Vaughan, North York, York, Etobicoke and the City of Toronto. The basin, bounded on the east by the Don River and on the west by the Mimico and Etobicoke Creeks, empties into Humber Bay, on Lake Ontario just west of the Toronto Islands.

3.2 LAND USE

Upper Humber

The 537 km^2 of the Humber watershed north of Steeles Avenue is predominantly rural. Rural land, including open areas and forested land, makes up about 97% of the catchment (TAWMS, TR# 8*, 1986). The small amount of urban land in the watershed is contained within small, mostly residential communities such as Bolton, Kleinburg, Nobleton and Woodbridge.

Agriculture is the main land use in the upper Humber catchment, composing 69% of the land use in the main Humber, 81% in the East Humber, and 87% in the West Humber (TAWMS, TR# 8, 1986).

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* TAWMS Technical Reports are referenced as TAWMS TR#

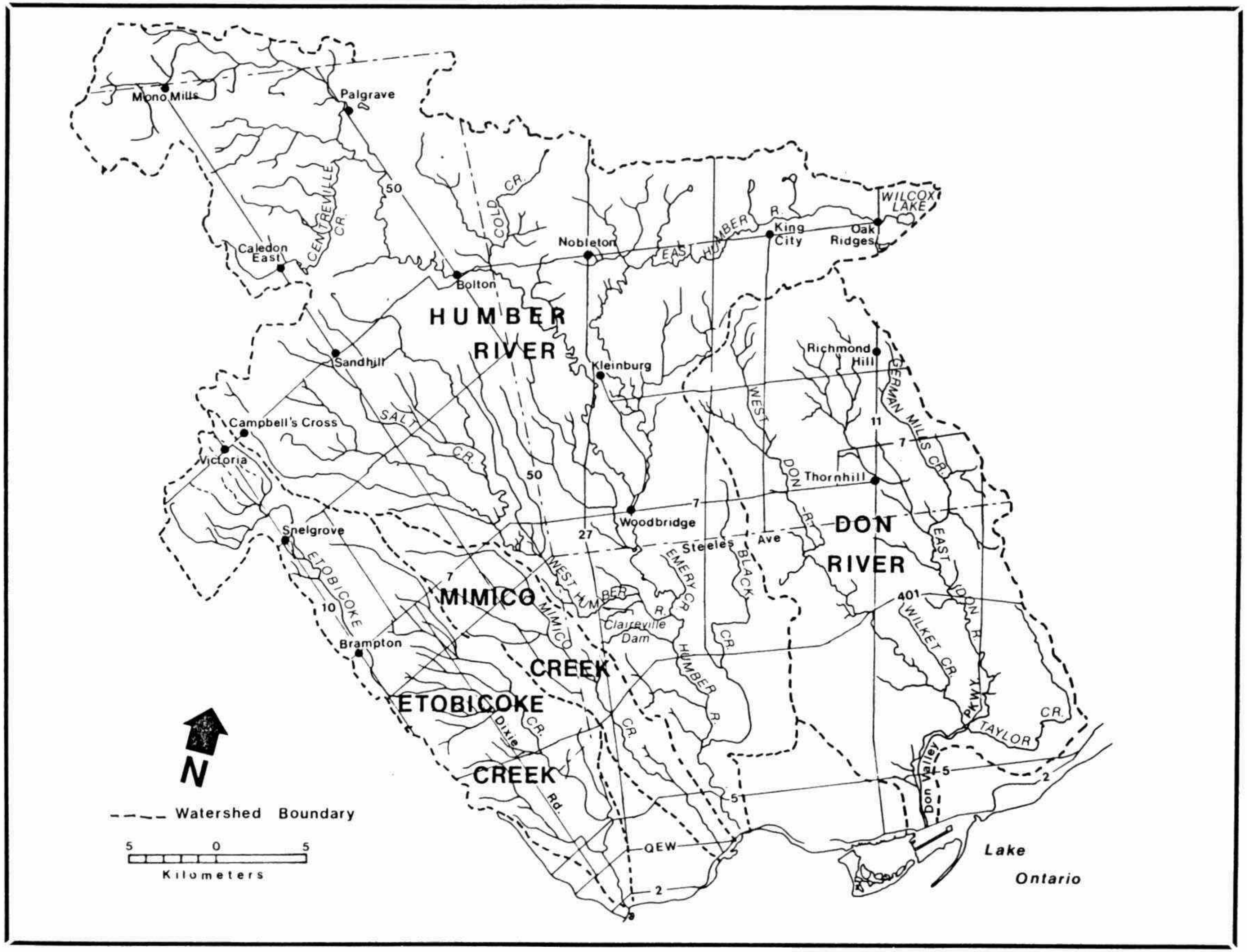


FIGURE 3.1 LOCATION OF STUDY WATERSHED

Pasture land tends to predominate in the northern catchments of the upper Humber. The amount of pasture land in the West Humber is much smaller, however it is located along the watercourse increasing its importance as a potential pollution source. As the Humber leaves the Oak Ridges Moraine and flows over the gently sloping till plain, pasture land gives way to crop land. The chief urban land uses in the upper Humber watershed are the communities of Bolton and Woodbridge.

Lower Humber

South of Steeles Avenue the Humber River flows through a highly developed portion of Metropolitan Toronto. Figure 3.2 shows the relative amounts of different land use types in the catchments discharging into the lower Humber. The land use of the lower Humber watershed is 34% low density residential, 12% high density residential, 13% industrial, and 41% open land. The most highly developed tributary area is that draining to the Humber between Lawrence Avenue and Eglinton Avenue. This area is 46% industrial and high density residential land and only 21% open land. Lower Black Creek is the catchment with the smallest amount of open land - 15%.

Development Trends

Table 3.1 shows existing and forecast future development in the Humber watershed. Anticipated development along the lower Humber in Metropolitan Toronto is minimal being limited to some redevelopment. Development is expected, however, in the upper reaches. For instance, the developed area in Brampton is expected to increase from 10% in 1983 to 35% by 2000, and from 5% to 12% in Vaughan. The developed area in the entire Humber watershed is expected to increase from 18% in 1983 to 22% by the year 2000.

This projected increase in developed area is not expected to come about through a reduction in forest or open land. Rather it will

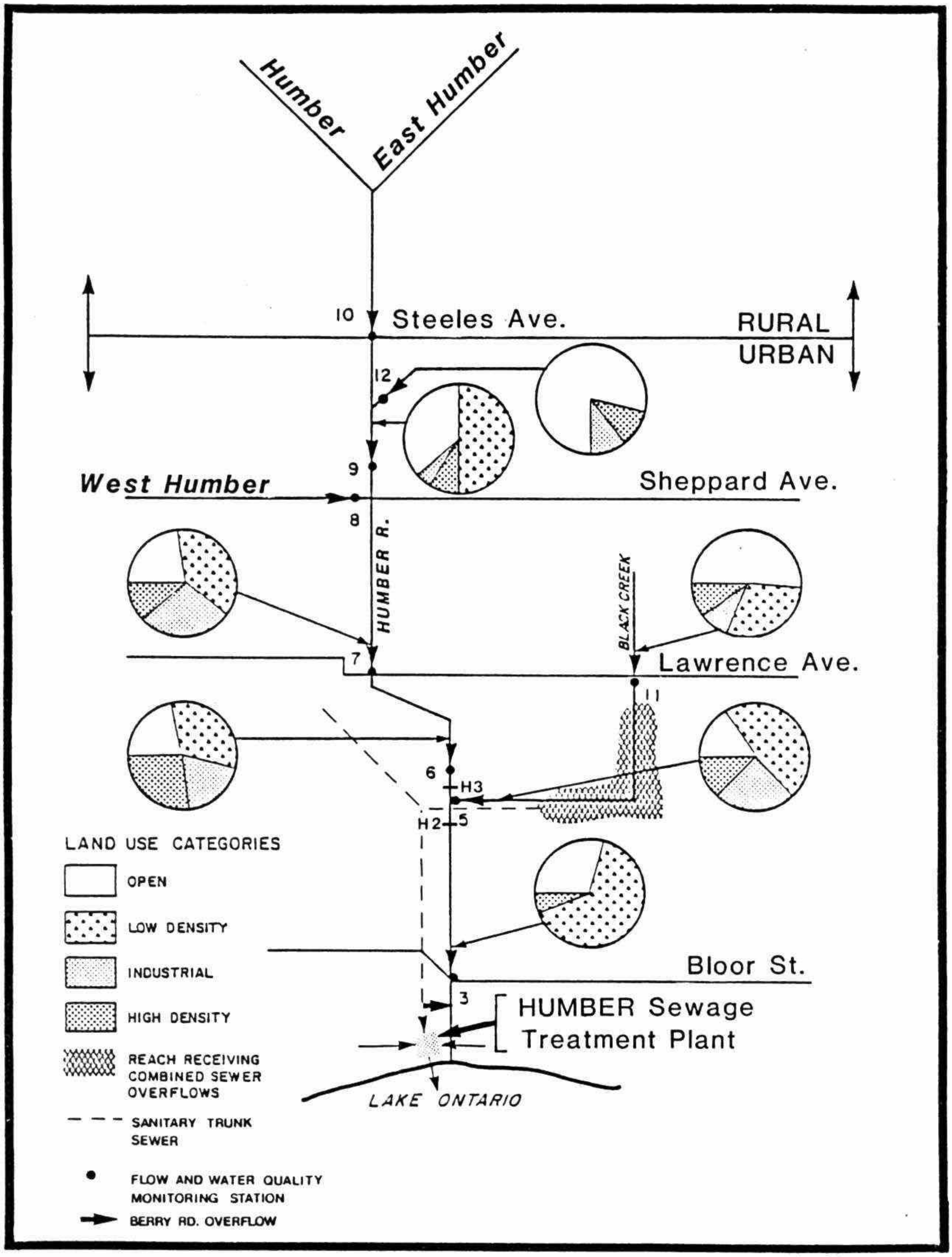


FIGURE 3.2 : HUMBER RIVER STUDY AREA

TABLE 3.1 : EXISTING AND FUTURE DEVELOPMENT IN THE HUMBER WATERSHED

Municipality	Area (ha)	% Developed (1983)	% Developed (2000)
Mono	1701	0	0
Adjala	1831	2	2
Caledon	33163	3	8
Brampton	7203	10	35
Mississauga	85	100	100
King	14367	5	7
Vaughan	17759	5	12
Richmond Hill	1723	18	22
Metro Toronto	13318	84	85
Total	91150	16	22

TABLE 3.2 : EXISTING AND FUTURE LAND USE IN THE HUMBER WATERSHED

Land Use	Existing % (1983)	Future % (2000)
Residential/ Small commercial	10	11
Industrial/ Large commercial	5	6
Utility/ Institutional	<1	<1
Field Crop	60	56
Pasture	6	5
Rural Residential	2	5
Forest	8	8
Open Space	9	9

occur as a result of a shift in land use from pasture and field crops primarily to rural residential, accompanied by smaller increases in residential/small commercial and industrial/large commercial (Table 3.2)

The estimated population for the Humber watershed is approximately 480,000 people (1982) with approximately 386,000 in the urban portion south of Steeles Avenue. Population projections, based upon different assumptions of demographics (see, Min. of Treasury & Economics, 1985), range from 527,200 to 561,100 for the Humber Watershed in the year 2001. The overall population trend tends to be increasing up to 1991 then a general decrease in population to 2001. The population is relatively stable for Metropolitan Toronto while the areas of Brampton, Caledon, Richmond Hill and Vaughan show significant population increases and corresponding predicted future development.

3.3 WATER RESOURCES

Surficial Soils and Drainage Pattern

From its source in the moraine hills near Orangeville, the main stem of the Humber River falls approximately 400 m over its 90-km journey to Lake Ontario (James F. MacLaren, 1979). Soils in the upstream areas are mostly sand. There are many small impoundments having no apparent connection to the main stream.

The West Humber River drains approximately 200 km^2 of the Peel Plain before joining the main Humber at Thistledown. Soils of the watershed are impervious clay drained by a dense drainage network. Owing to the steep stream gradient and the low soil permeability, the West Humber flood potential is high.

The East Humber River rises in a region with topography similar to that of the upstream areas of the main Humber River; however, less

of the catchment is covered by pervious soil. The East Humber drains an area of 197 km^2 before joining the main Humber at Woodbridge.

Figure 3.3 shows the profile of the Humber River and its major tributaries. It indicates that the urbanized portion, below Steeles Avenue to Bloor Street, is relatively steep. A field survey confirmed that this portion has enough self-cleaning capacity, i.e., no signficant sediment deposits in its main channel (TAWMS, TR# 3, 1984). Therefore, it may be classified as a stream section with the transport mechanism controlled by the supply of sediment. Minimal deposits were found behind several weirs between Dundas and Bloor Streets. Figure 3.3 also shows that the portion of the Humber River below Bloor Street is extremely flat and therefore has the highest potential for sedimentation of any portion of the river.

Precipitation

Precipitation occurs in Toronto on about 140 days each year (James F. MacLaren, 1979). Mean annual precipitation is 790 mm. Annual and monthly precipitation are quite uniform. There is less than a 25 mm difference between average precipitation in the month of highest precipitation (August, with 81 mm) and the month of lowest precipitation (February, with 57 mm).

During the summer, most rainfall in Toronto occurs as afternoon or evening showers or thunderstorms. These storms are most frequent in July and they tend to fall on limited areas. Mean annual rainfall is about 650 mm and is distributed fairly evenly throughout the Toronto area (James F. MacLaren, 1979).

Most precipitation in the winter falls as snow. About half of the average snowfall occurs in January and February. Mean annual snowfall is about 1400 mm with considerable variation in snowfall in the Toronto area (James F. MacLaren, 1979).

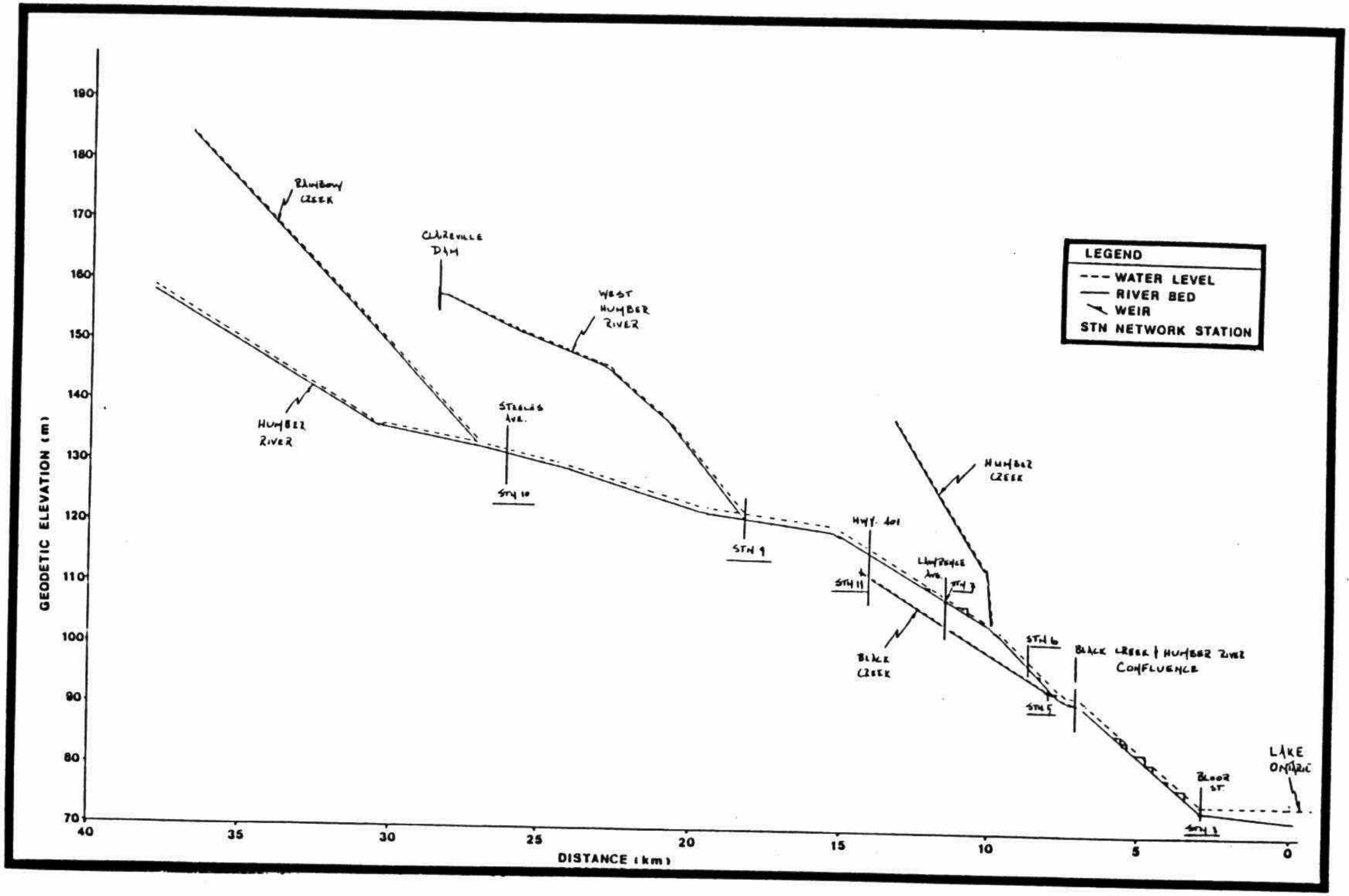


FIGURE 3.3 : PROFILE OF THE HUMBER RIVER AND TRIBUTARIES

Hydrology

There are considerable differences in flow characteristics at different stream gauging stations in the Humber watershed (Table 3.3). For instance, the average annual peak flow per unit area for Black Creek is over six times higher than that for the Humber River at Elder Mills. This higher peak flow is attributed to the greater urbanization of Black Creek. The comparatively high average annual peak flow per unit area for the West Humber River at Claireville, a mostly rural watershed, results from the heavy, impervious clay soils and uniform, open slopes of the watershed. The West Humber has been regulated by the Claireville Dam (Figure 3.1) since 1964. The reservoir is operated for flood control and low flow augmentation.

Considerable differences are also apparent in the low flows in the Humber watershed (Table 3.3). The lowest flow is on the West Humber River and results from the low infiltration through the impervious clays of the Peel Plain to deep soil moisture zones that supply baseflow. The higher baseflow for the Humber River at Elder Mills results from the higher permeability of soil in the upstream portions of the watershed. This soil absorbs much of the precipitation in this area and releases it to the river as baseflow.

As a watershed becomes urbanized, its baseflow normally decreases. Note, however, that the 2-year, 7-day low flow for Black Creek, a highly urbanized catchment, is the highest of any in Table 3.3. This might be caused by water imported into the catchment from Lake Ontario through the municipal water supply and subsequently released into the storm sewer system.

Figure 3.4 shows average monthly discharges of the Humber River at Lawrence Avenue (Humber River at Weston federal flow gauging station) based on 35 years of record. In the Humber watershed, peak monthly discharge occurs in March or April and low flow occurs in August or September. For the purposes of this study, simulations

TABLE 3.3 : PEAK AND LOW FLOWS AT SELECTED WSC STREAM GAUGES IN THE HUMBER WATERSHED*

Gauge Location	Gauge Number	Drainage Area (km^2)	Average Annual Peak flow ($x10^{-3}$ $m^3/(s.km^2)$)	2-year 7-day low flow** ($x10^{-3}$ $m^3/(s.km^2)$)
Elder Mills	02HC025	303	100	2.68
Pine Grove	02HC009	197	168	0.75
Claireville	02HC034	194	253	0.06
Weston	02HC003	800	149	0.71
Black Creek	02HC027	58	632	3.67

* Source of data: James F. MacLaren, 1979

** The 2-year, 7-day low flow is the 7 day average low flow with a probability of exceedence of 50% in any given year (ie. a 2 year return period).

were carried out for the period April 1979 to March 1980. The average monthly flows for this period are also plotted in Figure 3.4. In general, the flows for the design year correspond well to the long term average flows.

3.4 DRAINAGE

Rural

The primary point source inflows in the upper reaches of the Humber River are natural. Point sources also occur, mainly from pastoral, residential, or small commercial land uses (TAWMS, TR# 8, 1986). There are storm sewer outfalls at Bolton and Woodbridge and Water Pollution Control Plant (WPCP) outfalls at Bolton and Kleinburg. The WPCP at Bolton will cease discharging to the Humber River in the fall of 1985. The Kleinburg plant is expected to continue operation and a plant expansion is anticipated in the future. There are also man-made inputs to the East Humber from King City, Oak Ridges, and the developed land along Highway 400. The principle man-made inflows to the West Humber are from agricultural activities.

Urban

The lower Humber River watershed in Metropolitan Toronto south of Steeles Avenue is largely developed except for land in river floodplains. Four constituent cities of Metro Toronto are situated either partly or wholly in this area. They are the Cities of Etobicoke, North York, Toronto and York.

The City of York is serviced predominantly by combined sewers which convey both sanitary wastewater and stormwater runoff. The other cities are serviced by a separate sewer system comprising a sanitary sewer network and a storm sewer network. Both the combined sewer and separate sewer areas share the same Metro trunk sanitary sewers for conveyance of their sewage to the Humber Water Pollution Control

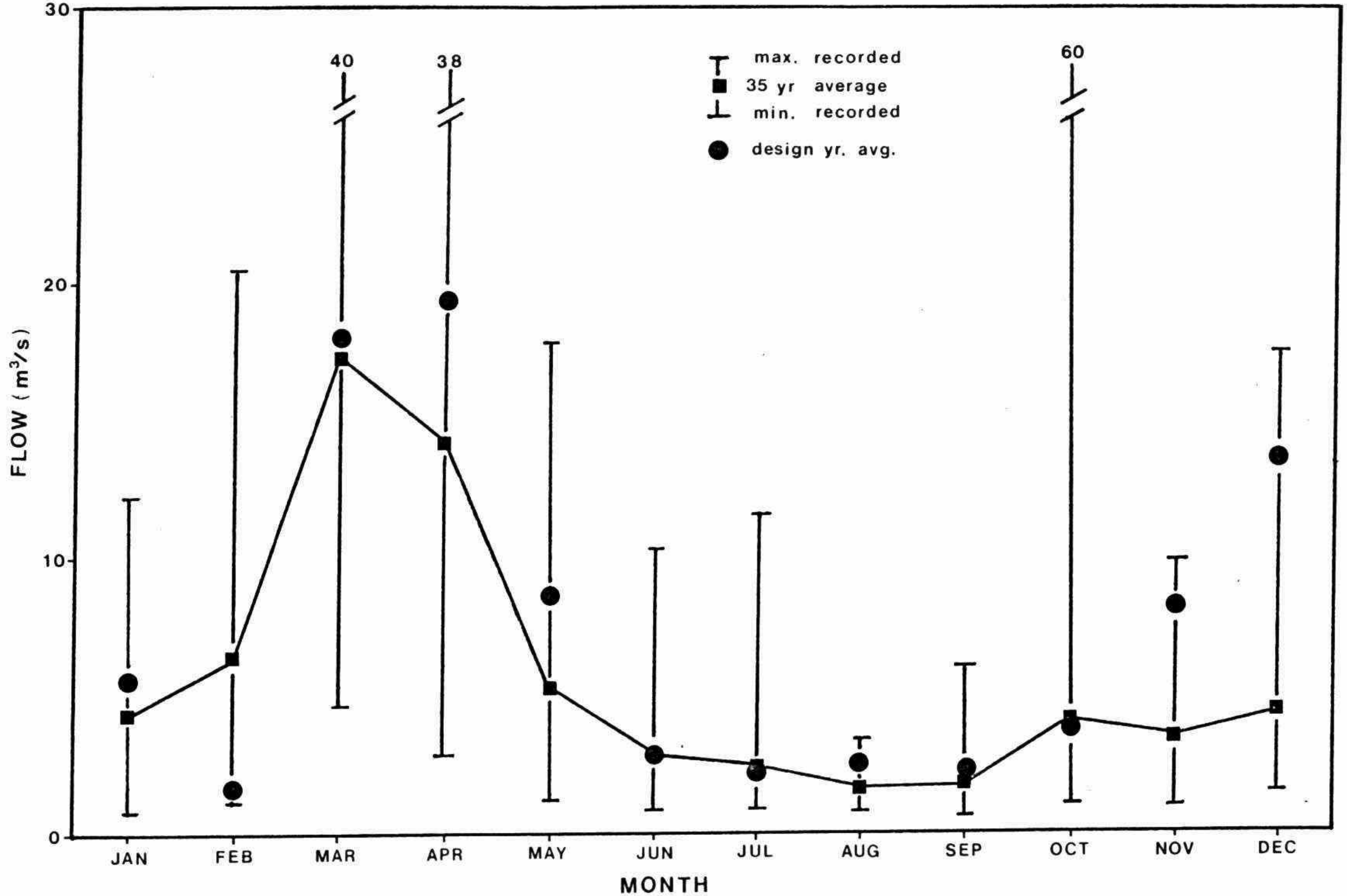


FIGURE 3.4 : AVERAGE MONTHLY FLOWS – HUMBER RIVER AT WESTON

Plant (WPCP) for treatment (Figure 3.2). The WPCP is a secondary treatment plant and has sufficient capacity to treat the sewage it receives in dry and wet weather under existing development and sewerage conditions.

Combined Sewer Area

The combined sewer area was mostly developed between the 1920's and 1950's and is generally a few decades older than the separate sewer area (TAWMS, TR# 1, 1983). The combined sewer area's population density is more than double that of the separate sewer area; the dry-weather flow per capita is approximately 60% of that from the separate sewer area; and the industrial land usage is much smaller.

In the combined sewer, the dry weather flow is essentially sanitary wastewater, however, during wet weather conditions the flow is a mixture of both sanitary wastewater and stormwater runoff. The occurrence of combined sewage is intermittent and coincides with the occurrence of runoff. In the Toronto area, the average interval of occurrence of wet weather during the summer is approximately 3 days (TAWMS, TR# 7, 1986).

As the combined sewage flow rate increases during a wet weather event the capacity of the combined sewer interceptor will be exceeded. The interceptor limits the rate at which combined sewage is drained to the WPCP. Excess flow will then be diverted from the system partly to a detention tank, with the remainder overflowing to Black Creek via 3 main regulators set in the sewers between Eglinton and St. Clair Avenues (TAWMS, TR# 7, 1986). The detention tank has a capacity of 7800 m^3 and when full also overflows to Black Creek. The detained flow is returned to the WPCP after a storm.

Increased flow rates during wet weather events can also exceed the capacity of the existing combined sewer system resulting in the flooding of basements. Flooding records dating back to 1976 indicate that the most severe flooding within the City of York

occurred during the summer of 1977 whan roughly 2000 to 3000 homes were flooded. The depths of water in the basements varied from 5 mm to 900 mm. More recently, as a result of ongoing flood relief works, a lesser number of homes (approximately 70 to 280) have experienced basement flooding problems in the summers of 1982, 1983 and 1984. Computer simulations of the combined sewer system have shown that the 10 year design storm will result in basement flooding within roughly 25 percent of the combined sewer area (TAWMS, TR# 9, 1986).

Separate Sewer Area

Within the separate sewer system, sanitary wastewater is conveyed to the WPCP through the sanitary system. Stormwater runoff passes through the storm sewer system directly to receiving waters, the Humber River and tributaries. Surface imperviousness and land use characteristics are prime factors affecting the quantity and quality of stormwater runoff, and are summarized in Table 3.4.

Building foundation drains can have an impact on the quantities of sanitary sewage, however, no comprehensive data on the disposition of foundation drains is available. It appears that homes constructed prior to the 1960's have drains connected to the sanitary system, and newer homes have foundation drains connected to the storm sewer system.

There are approximately 600 storm sewer outfalls within the urban drainage area (TAWMS, TR# 1, 1983). The average catchment size per outfall is 28 ha, which is equivalent to half the size of a housing subdivision.

3.5 WATER USES

The Humber River is used for irrigation, livestock watering, aquatic recreation, and provides fish and wildlife habitat. The Humber River is not used as a source of drinking water.

TABLE 3.4 : SEPARATE SEWER AREA CHARACTERISTICS

	Residential		Commercial	Industrial
	Low/Medium Density	High Density		
Surface Imperviousness (% of Land Use Area)	38-51	52-67	67-92	58-70
Connected Imperviousness (% of Land Use Area)	26-34	49-61	62-92	34-68
Roof Area (% of Land Use Area)	19-28	13-40	25-37	18-29
Street Area (% of Land Use Area)	9-13	7-14	9-20	6
No. of Catchbasins per Street Block	6-7	5-7	8-12	11-19

There are permits for formal water-taking; a permit is required for taking water from the river if the withdrawal of water is greater than 50,000 L/day. Water is withdrawn from the lower Humber River to irrigate two golf courses adjacent to the Humber River. In addition, there are a few permits for water withdrawal in the upper Humber for recreational purposes. Livestock watering does not require a permit.

The upper Humber watershed contains several conservation areas that provide opportunities for swimming, fishing, boating and general outdoor recreation. There are swimming areas in the Albion Hills, Boyd, and Claireville conservation areas. Windsurfing is permitted at Wilcox Lake near Oak Ridges and at Claireville Conservation Area where boating is allowed as well. The use of swimming areas here has been curtailed or severly restricted due to bacterial contamination at these areas. There are plans to develop a water park in the future at Claireville Conservation Area.

The lower Humber River consists of parkland and golf courses that potentially provide numerous recreational opportunities. There are no formal swimming areas in the lower Humber River, however, there are many areas along the river where swimming would be possible. Even though the water quality is degraded, many children and adults swim and wade in the lower Humber, especially in the vicinity of numerous weir structures.

There is fishing throughout the Humber River, and in particular in the lower Humber, for both resident and migratory fish. In late summer, many anglers fish for migrating salmon. The Ministry of Natural Resources (MNR) is developing a District Fisheries Management Plan which will include priorities for the Humber River and has developed a successful "put and delayed take" brown trout fishery at the mouth of the Humber River.

The marshes (or portions thereof) in the lower Humber have been identified as an Environmentally Significant Area (ESA) in the MTRCA's ESA study with significant vegetation, wildlife and

hydrologic features. These marshes also provide important spawning and nursery habitats for Lake Ontario fish.

The lands along the Humber River are under the general jurisdiction of the MTRCA, and are regulated under MTRCA's overall mandate for flood protection and natural resources management. Many land areas along the Humber River have been acquired by MTRCA, and are regarded as a great natural asset with important recreational features. These lands are generally left as open space to serve as a buffer between developed areas and the river.

The safety and scale of use of all the above recreational activities are directly related to water quality improvements. Aquatic recreation involving body contact with the water is a cause of concern for the health and safety of users under existing conditions. Aquatic habitats and communities would benefit from any water quality improvement which would reduce environmental stresses and the potential for contaminant bioaccumulation.

4. EVALUATION PROCEDURES AND CRITERIA

4.1 PURPOSE

A water quality management plan comprises a discrete set of measures to be undertaken in a comprehensive manner in order to achieve a certain level of improvement in the water quality condition. Alternative management plans, varying in the specific combination of component measures, will provide varying levels of improvement in water quality with corresponding variations in cost, ease of implementation and perhaps the level of achievement of other water resources management goals. It is necessary to evaluate each management plan fully in order to enable management agencies to select a preferred plan from among the alternative plans. This chapter outlines the criteria used in TAWMS to evaluate management plans and briefly describes how they are used.

The evaluation criteria are discussed below under the general categories of water quality, flood control, economic impact and implementability.

4.2 WATER QUALITY

As described in the introduction, surface water quality impairment was identified in the Humber River. As such, water quality degradation may have a negative impact on some water uses, that is, to limit or prohibit these uses.

The goal for surface water quality management of the Ministry of the Environment is:

> "to ensure that the surface waters of the Province are of a quality which is satisfactory for aquatic life and recreation."

This goal is embodied in the publication "Water Management Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment" (MOE , 1984). Provincial Water Quality Objectives (Table 1, MOE, 1984) and guidelines provided in this publication are a set of narrative and numerical criteria based on water quality requirements to safeguard public health, maintain aesthetically pleasing conditions and protect aquatic life, and are summarized in Table 4.1.

As part of MTRCA's Watershed Plan, the Conservation Land Management Program was developed to:

> "Contribute to the quality of land and water resources through a comprehensive program of conservation land management including forest management, source area protection and conservation land planning."

One of the objectives of the program is to enhance the fisheries habitat on all streams through a program of stream improvement, with particular attention given to expanding the cold water fisheries potential. To achieve this objective, MTRCA is currently undertaking stream assessment and inventories which will assist in the prioritization of the stream improvement program. MTRCA has undertaken numerous stream improvement and physical rehabilitation projects in the upper Humber River. The stream improvement program is also concerned with warm water fisheries which requires the investigation of the urban potential for this type of fisheries.

In 1976 the MTRCA and the Ministry of Natural Resources (MNR) undertook a study entitled "Operation Doorstep Angling". The report examined both MTRCA and public lands for potential angling opportunities and made management recommendations to improve the fisheries potential. These recommendations include the stocking of fish to ensure an adequate fish population and improvements to the aquatic habitat. Its conclusion stated that there was indeed a need to increase angling opportunities in and around Metropolitan Toronto and at the same time improve the fish habitat in the same area.

TABLE 4.1 : SELECTED PROVINCIAL WATER QUALITY OBJECTIVES AND GUIDELINES

	Objective	Guideline
Inorganics and Other Parameters		
pH	6.5-8.5	
Ammonia	0.02 mg/l	
Chlorine	0.002 mg/l	
Cyanide	0.005 mg/l	
Dissolved Oxygen	4 - 8* mg/l	
Phenols	0.001 mg/l	
Phosphorus, Total		0.03 mg/l (rivers) 0.01 mg/l (lakes)
Heavy Metals		
Arsenic	0.1 mg/l	
Cadmium	0.0002 mg/l	
Chromium	0.1 mg/l	
Copper	0.005 mg/l	
Iron	0.3 mg/l	
Lead	0.005 -0.025** mg/l	
Mercury+	0.0002 mg/l	
Zinc	0.03 mg/l	
Pesticides		
Dieldrin	0.001 ug/l	
Endosulphan	0.003 ug/l	
Heptachlorepoxide	0.001 ug/l	
DDT and Metabolites+	0.003 mg/l	
Industrial Organics		
PCB+	0.001 mg/l	
Bacteriological Indicators		
Fecal Coliforms++	100 organisms per 100 ml	
Total Coliforms++	1000 organisms per 100 ml	

* Temperature dependant
** Alkalinity dependant
\+ Objective intended as guidance for dealing with past relases or accidental losses, these substances have a zero tolerance limit.
++ Geometric mean density for a series of samples

The provision of urban or doorstep fishing opportunities provides recreation for many, regardless of age, socio-economic status or physical handicaps. In addition, therapeutic benefits derived from the fishing experience include not only exercise and a day outside, but also emphasize fishing as a reducer of stress.

The objectives for heavy metals represent values that should not be exceeded in individual samples. Achievement of these objectives within the Humber River and its tributaries are assessed in terms of reductions in the frequency of exceedences and the degree of exceedence in terms of both magnitude and duration. Since these objectives also apply to receiving waters in Humber Bay, impacts are also expressed in terms of reduction in total loadings of these metals at the Bay.

A potential health hazard exists when pathogenic organisms (eg. Pseudomonas aeruginosa, Salmonella typhii, and Polio virus), can be enumerated and frequently isolated from the water. Bacteriological water quality indicators are groups of bacteria whose densities in water can be related quantitatively to the presence of sewage or fecal matter, and therefore to the risk of contracting a disease from the pathogens contained therein. The fecal coliforms are one of these indicators. A potential health hazard exists if the fecal coliform geometric mean density for a series of water samples exceeds 100 per 100 ml. The analysis of bacteria focuses on mean densities of indicator bacteria rather than exceedence frequencies.

In keeping with the goal for surface water quality management, the Ministry of the Environment has developed several policies to ensure the goal is met. Specifically, policy 2 states that water quality which does not meet the objectives shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives (MOE, 1984). Policy 2 also states that evaluations of existing conditions in problem areas shall be conducted with the aim of developing effluent requirements (Policy 3). With this in mind a model sewer use bylaw has been developed

(MOE/MEA, 1984), in order to limit the contaminant input into the municipal storm and sanitary sewer systems.

In keeping with provincial policy the intent of this planning exercise has been to identify all practical measures to acheive Provincial Water Quality Objectives or at worst to prevent further degradation of existing conditions.

4.3 FLOOD CONTROL

Municipalities operate drainage systems with the aim of protecting private property and public areas from flooding. As noted in Chapter 3, storm and combined sewer systems which are designed to pass runoff from a design storm of a given frequency of return, are at times overtaxed in the City of York, leading to basement flooding in localized areas. Consequently, TAWMS has as one of its water management objectives to prevent basement flooding. The level of protection is expressed in terms of the frequency (or return period in years) of storms which can cause flooding. The City of York's sewer separation program's objective will achieve a protection level for a 2 year design storm. Alternative flood protection schemes shall have a protection level for a 10 year design storm as specified by the City of York.

Flood control is an objective in TAWMS since measures designed to prevent water quality impairment due to combined sewer overflows may also conceivably affect basement flooding. It is important to determine whether water quality and flood control objectives are related and to identify the nature of any interdependence between these objectives.

4.4 ECONOMIC EVALUATION

The principal economic analysis in TAWMS involved an assessment of project costs. These include the direct costs associated with a

project such as engineering and construction costs and the cost of operating and maintaining new facilities, as well as certain indirect costs associated with hydraulic impacts that combined sewer overflow control options can have on the Humber Water Pollution Control Plant. These costs are categorized either as intermittent lump-sum "capital" costs or recurrent "annual" costs.
The approach to economic analysis in TAWMS involved a comparison of cost and impact data and the relative degree of achievement of planning goals in order to identify the alternative with the best overall profile. This is called cost-effectiveness analysis.

The objective of the analysis is to reject at the prescreening stage, any alternatives which are clearly inferior and then to select, among the remaining alternatives, the project or projects which will provide the preferred combination of cost and goal attainment. Often the preferred alternative will occur at a point beyond which further water quality improvements become prohibitively expensive or the return to additional dollars of expenditure becomes very small.

Within the TAWMS study, economic evaluation using cost-effectiveness analysis procedures have assumed a 20 year planning horizon and a discount rate before inflation of 7% (Fortin, 1985). With prevailing rates of inflation, this discount rate would be equivalent to a market rate of about 10%. With these assumptions, the capital and annual costs have been summarized in the form of a total capitalized or present value cost.

4.5 IMPLEMENTABILITY

The implementability of options encompasses technical feasibility as well as public and agency acceptance. Technical feasibility is a prerequisite that forms the basis for an early pre-screening of options. Technical feasibility can relate to land availability (ie.

an area that is totally developed with little or no open space) or to inferiority (ie. minimal water quality impact).

Public acceptance includes enforceability of bylaws such as those relating to the control of illegal sewer connections, and canine control. Public acceptance is also important for options which include a change in land-use such as stormwater ponds and storage tanks; these must be evaluated for their impact on the neighbouring public. Jusrisdictional and land use conflicts may give rise to conflict among agencies and jeopardize agency acceptance of certain options.

5. SURFACE WATER QUALITY CHARACTERIZATION

A variety of studies were conducted as part of the TAWMS program to characterize surface water quality in the Humber watershed. The initial study was a review of historical water quality data supplemented by a limited sampling program (MOE, 1983). This was followed by a program of intensive sampling of the Humber River and Black Creek during dry weather, storm events, and spring runoff (TAWMS, TR# 4, 1984). Sediment sampling and clam bioaccumulation studies were also part of this program. These Humber River water quality studies showed that the quality of the Humber system north of Steeles Avenue was also of concern. Accordingly, a dry and wet weather sampling program was subsequently conducted on the upper Humber (TAWMS, TR# 8, 1986). In addition, special studies were conducted in the lower Humber into sediment contamination (TAWMS, TR# 10, 1986) and bacterial contamination (TAWMS, TR# 6, 1985).

5.1 UPPER HUMBER RIVER WATER QUALITY

Fecal coliform counts regularly exceeded the Provincial Water Quality Objective (PWQO) during dry and wet weather at most sampling stations, including those in the relatively undeveloped upper reaches. Exceedences were more pronounced during wet weather, and wet weather exceedences on the West Humber and East Humber were greater than those on the main Humber. Bolton and Woodbridge each contain several point sources that proved to be potentially significant dry weather sources of fecal pollution.

The sub-catchments between Bolton and Woodbridge contributed the greatest dry weather loadings of Total Suspended Solids (TSS). These sub-catchments also had significant loadings of Total Phosphorus (TP). Appreciable loading of TP was also found upstream in the town of Bolton. Stream bank erosion and livestock access may account for the TSS and TP increases between Bolton and Woodbridge. Wet weather exceedences of the total phosphorus PWQO were widespread

throughout the upper Humber. TSS and TP concentrations were generally higher in wet weather than in dry weather.

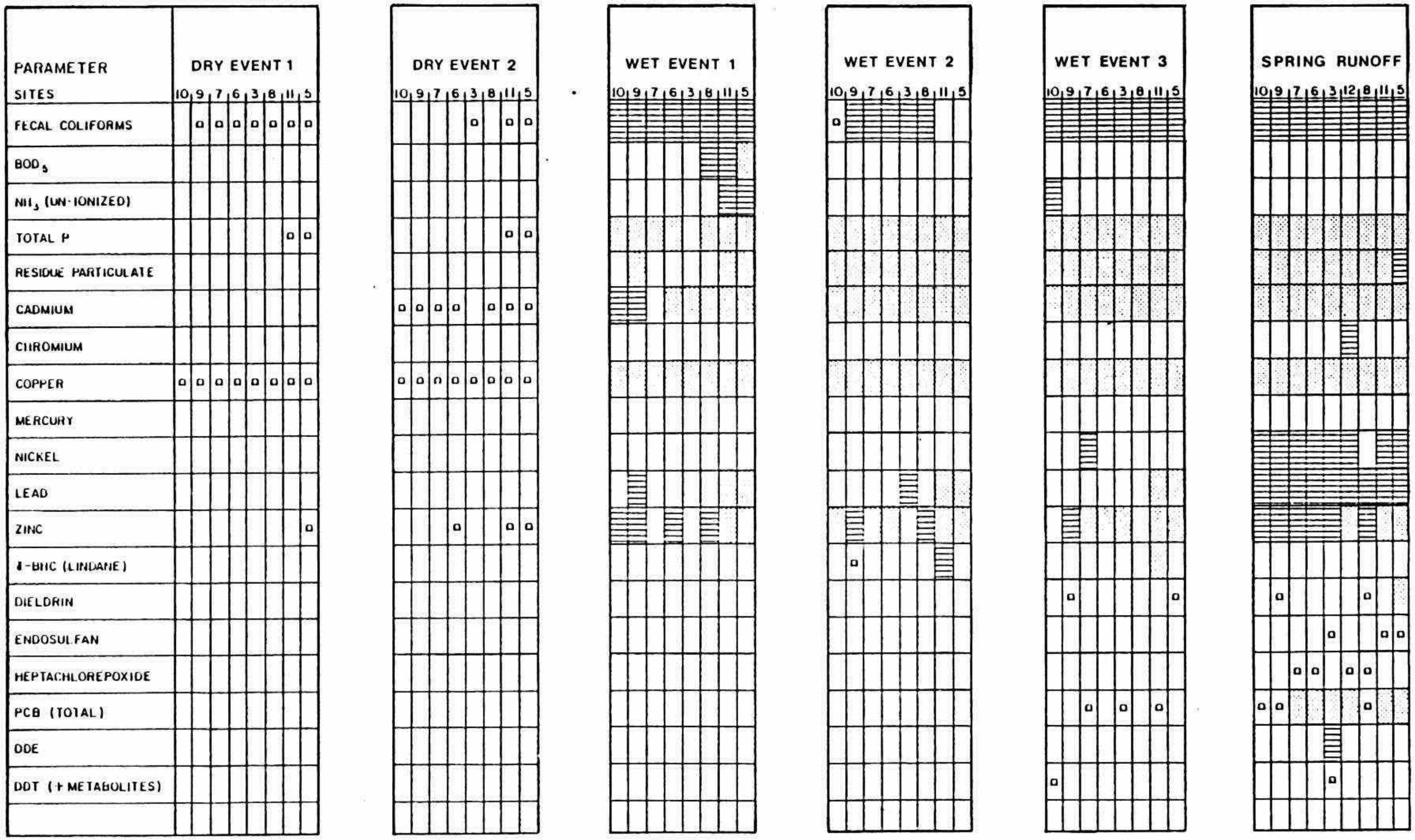
Few significant differences between stations or weather-related differences were seen in copper or lead concentrations. Cadmium concentrations, however, were more variable in the study area and they increased dramatically under wet conditions.

Chemical and microbial concentrations were lower during dry weather in the late fall than in the summer and early fall dry events. This suggests that there is a seasonal variation in pollutant sources and stream flow influenced by seasonal changes in land use practices and weather.

5.2 LOWER HUMBER RIVER WATER QUALITY

For most of the conventional water quality parameters, concentrations were highest during runoff events and lowest during dry weather (TAWMS, TR# 4, 1984). On the other hand, total ammonia, pH and total dissolved solids (residue filtrate) concentrations were generally higher during dry weather than during runoff events. The behaviour of total ammonia, total phosphorus, and fecal coliforms was different in Black Creek than in the Humber River, suggesting different sources of these parameters in Black Creek. Highest concentrations of most parameters were found at the mouths of Black and Emery Creeks, both of which are industrialized catchments. Biochemical oxygen demand (BOD) levels were generally low throughout the lower Humber. As well, no dissolved oxygen problems were identified (Bacchus, 1984).

As shown in Figure 5.1, the parameters that most consistently exceeded Provincial Water Quality Objectives at stream water quality stations were fecal coliforms, cadmium, copper and zinc. The guideline for total phosphorus in streams was frequently exceeded during runoff events; lead and PCB often exceeded Objectives during



LEGEND

- > 50% OF SAMPLES EXCEEDED OBJECTIVE OR GUIDELINE
- ≤ 50% OF SAMPLES EXCEEDED OBJECTIVE OR GUIDELINE
- THE ONE VALID SAMPLE EXCEEDED OBJECTIVE OR GUIDELINE
- SAMPLE WITHIN OBJECTIVE OR GUIDELINE OR NO VALID SAMPLE OBTAINED

STATION LOCATIONS (upstream-downstream order)

10 Humber R. at Steeles Ave.	3 Humber R. at Bloor St.
9 Humber R. at Sheppard Ave.	8 West Humber R. at Humber R.
7 Humber R. at Lawrence Ave.	11 Black Cr. at Lawrence Ave.
6 Humber R. at Scarlett Rd.	5 Black Cr. at Humber R.

FIGURE 5.1 : OCCURENCE OF EXCEEDANCES OF WATER QUALITY OBJECTIVES GUIDELINES

runoff. Exceedences were most common and severe at the sampling sites at the mouths of Black Creek, Emery Creek and the downstream portion of the lower Humber River. Exceedences were generally less common at upstream sites on the Humber River. Significant exceptions to this generalization, however, were cadmium and copper, which usually exceeded their Objectives even at the most rural site on the lower Humber River.

Bacteriological Quality

In the bacteriological study carried out in the fall of 1983 (TAWMS, TR# 6, 1985), the parameters monitored included Fecal Coliforms (FC), Fecal Streptococci (FS), enterococci, *Escherichia coli* (*E. coli*), and *Pseudomonas aeruginosa* (*P. aeruginosa*). A provincial water quality objective exists for FC only. IJC recommended objectives (IJC, 1983) were used to interpret the behaviour of enterococci, *E. coli*, and *P. aeruginosa*. For dry weather conditions, the geometric mean densities were in non-compliance with the objectives in the case of:

- o FC at all stations;
- o Enterococci in the Humber River at Lakeshore and Dundas, and in Black Creek at Scarlett and Lawrence;
- o *E. coli* at all stations;
- o *P. aeruginosa* at all stations except the Humber River at Dundas and Steeles.

The study stations are indicated in Figure 3.2. Results from other studies have also indicated that the in-stream bacteriological water quality is in non-compliance with the PWQO and IJC recommended objectives, with Black Creek being the most highly contaminated area (TAWMS, TR# 4, 1984).

Densities of FC, enterococci, *E. coli* and *P. aeruginosa* increased from upstream to downstream locations during dry weather at all stations except for a slight decline of *P. aeruginosa* in Black

Creek. These four bacterial parameters were in non-compliance with their appropriate objectives in all 10 samples taken from the sampling site at the mouth of Black Creek.

The geometric mean of each bacterial parameter for each wet weather event was in non-compliance with the objective for that parameter. There was an increase in the wet weather densities of various parameters from upstream to downstream locations as well, except for a decline in FS in Black Creek during the October event. As shown in Figure 5.2 the FC densities in Black Creek were generally much higher than those in the Humber River during wet weather events, as in the case of dry weather studies.

A comparison of dry and wet weather results indicates higher densities of each bacterial parameter in wet weather at each station, with enterococci showing the largest increase. The FC comparison is shown in Figure 5.2.

An evaluation of the impact of dry weather outfall FC and FS loading inputs on in-stream bacterial quality using a mass-balance, first-order die off model indicated that dry weather outfall loadings are one of the main sources of fecal contamination in the water courses with the possibility of the presence of additional FC bacterial sources in the Humber River upstream of the confluence with Black Creek.

Contaminants in Sediments

Sediment samples were collected from the lower Humber and several tributaries as part of an analysis of sediment transport and associated contaminant movement (TAWMS, TR# 10, 1986). Relationships between selected heavy metals and suspended sediment were also analysed. In addition, characterization of fine sediments by particle size distribution and chemical analysis of the particle fractions were made for samples collected along the entire reach from Steeles Avenue to Lake Ontario.

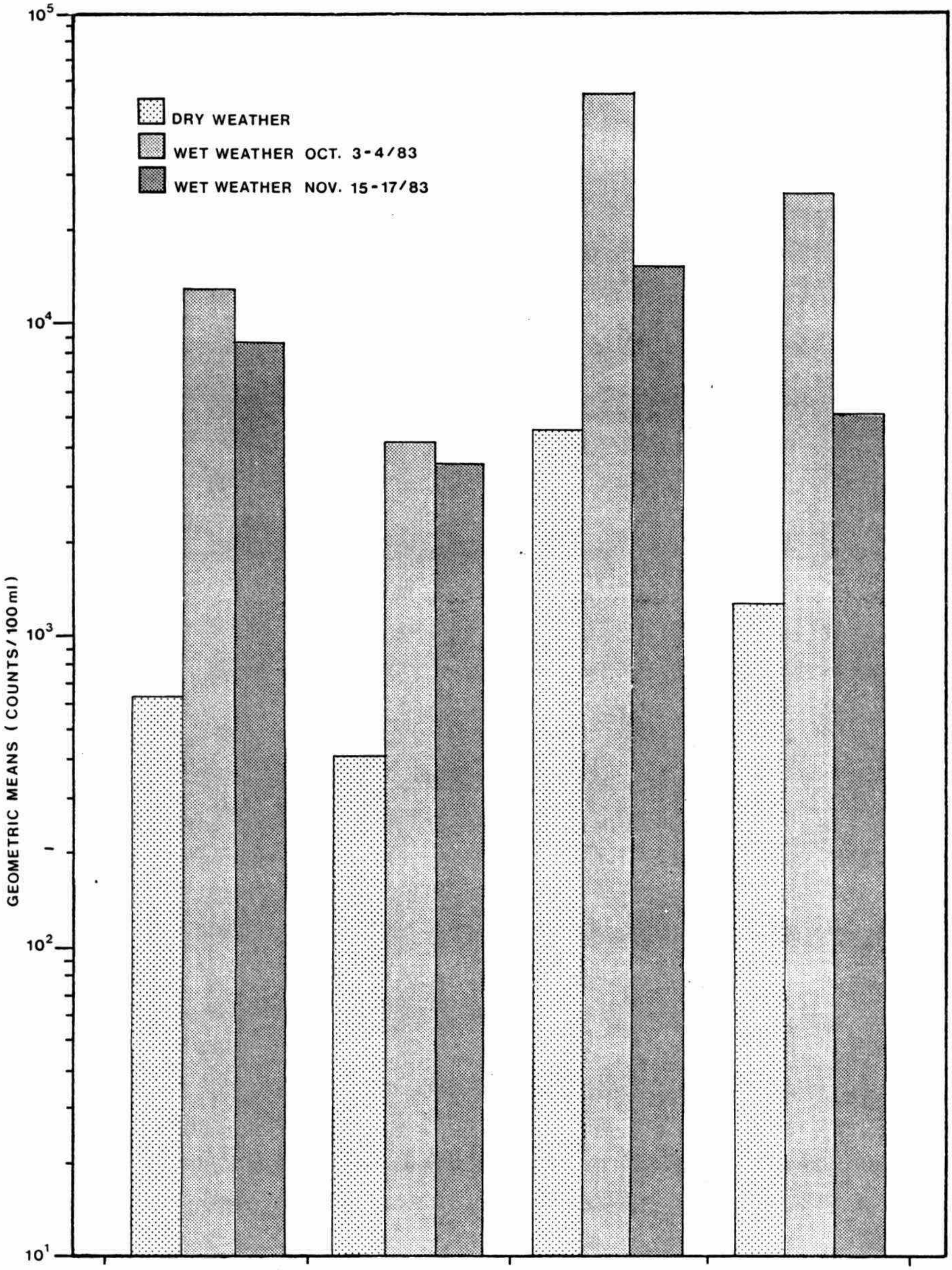


FIGURE 5.2 : DRY AND WET WEATHER FECAL COLIFORM BACTERIAL DENSITIES

Results indicate that the major portion of the annual sediment load occurs in the spring runoff period. Chromium, manganese, nickel, Total Phosphorus (TP), and Total Kjeldahl Nitrogen (TKN) concentrations are fairly uniform throughout the basin. Zinc, lead and cadmium show a marked increase downstream while copper has a slight increase. Lead, zinc, copper and chromium have a high number of guideline exceedences. Sediment within the highly urbanized tributary areas (Black and Emery Creeks) and the lower reaches of the Humber River was of a poor quality. The MOE guidelines for open water disposal of dredged material (Persaud and Wilkins, 1976), relate mainly to the chemical quality of the sediment and it should not be construed that levels of parameters in excess of the guideline necessarily imply detrimental direct water quality or biological effects.

Bioaccumulation in Clams and Fish

The bioaccumulation of toxic substances in clams was examined by placing clams in cages in the water for roughly 3 weeks and then sampling the clam tissue (TAWMS, TR# 4, 1984). PCBs and DDE were the organic compounds most prevalent in clam tissue. The highest levels of these compounds were found in clams suspended in Black Creek (Figure 5.3). The levels of most of the pesticides and organic compounds measured were usually below detection limits.

Young-of-the-year common shiners were collected from several locations in the Humber watershed in 1981 (MOE, 1983). These specimens were found to have accumulated detectable levels of PCBs, total DDT, total BHC, and total chlordane (Table 5.1). For each compound but PCBs, the lowest levels were found in samples obtained from the upstream Humber River stations at Finch Avenue and at Scarlett Road and the highest level was found in samples from Black Creek. The highest PCB levels were found in samples from the Scarlett Road station. These high PCB levels were more than twice the levels at the other stations, suggesting the possibility of a source of PCBs near Scarlett Road. Follow-up sampling of surface waters in this area did not reveal a specific source for the PCB's.

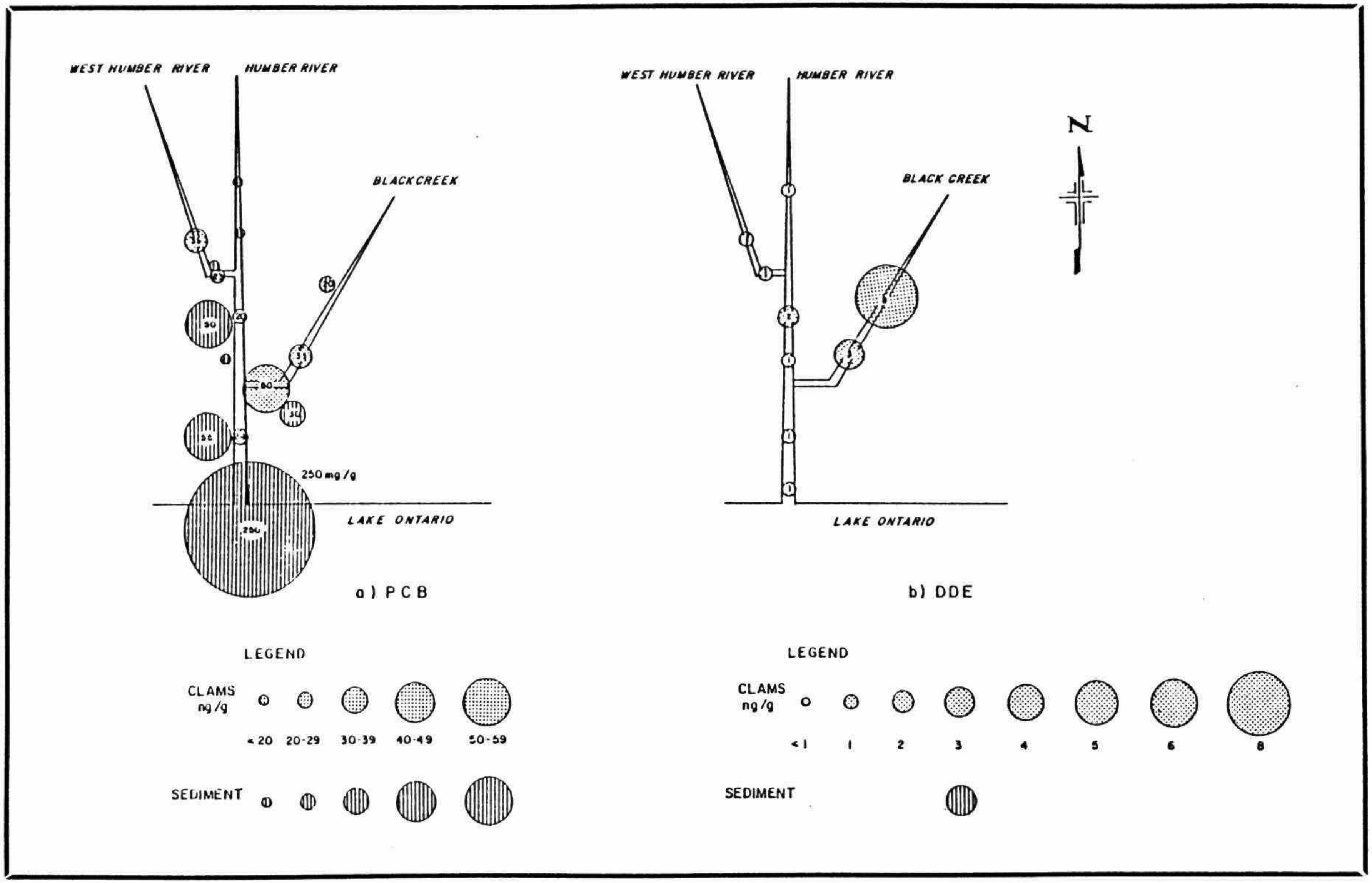


FIGURE 5.3: PCB AND DDE IN CLAMS AND SEDIMENTS

TABLE 5.1 : PCB AND ORGANOCHLORINE RESIDUES IN YOUNG-OF-THE-YEAR COMMON SHINERS, 1981*

Humber River Location	No. of samples	% Lipids	PCB (ng/g)	Total DDT (ng/g)	Total BHC (ng/g)	Total Chlordane (ng/g)
Finch Avenue	3	3.8	160	20	6	11
Scarlett Road	4	5.7	2282	15	6	9
Black Creek	4	6.1	1106	30	9	12
River Valley Cresent	5	3.4	1054	65	17	14

*Source: MOE, 1983

Spottail shiners collected from the mouth of the Humber River have shown declining PCB levels between 1977 and 1979 (Suns et al, 1981). The levels in samples collected in 1977 approached 2200 ng/g, where as levels in 1979 samples were about 1200 ng/g. Spottail shiners collected from this location in 1981 exhibited a further decline to about 950 ng/g (MOE, 1983).

5.3 HUMBER BAY

Humber Bay receives combined discharges from the Humber River and other sources that have direct impact on its condition. Existing conditions in the Humber Bay area of the Lake Ontario nearshore can be summarized under the following four headings:

Flow Structure

Currents were measured in Humber Bay during 1983-84. The general circulation was counterclockwise in the summer when currents out in the lake were from east to west. When lake currents reversed in the winter, however, circulation in the bay was clockwise. Eddies approximately 2 km in diameter occurred in the middle of the bay during summer. Monthly mean current speeds varied from 2.2 to 13.4 cm/s.

Drogue tracking experiments showed that Humber River water can intrude between the western breakwall and the shore under northerly winds. Residence times of water behind the breakwall varied from 1.5 to 12 hours.

Bacteria

During the summer, a combination of discharges from the Humber River and directly connected storm and combined sewers have resulted in beach closures at the Western Beaches due to exceedence of PWQO. Under dry weather conditions this is a localized problem occurring

at the mouth of the Humber River, and in the relatively shallow water near the Humber Bay breakwall. During wet weather events elevated bacterial levels occur up to approximately one kilometre offshore. High bacterial counts shoreward of the breakwall tend to be aggravated by the limited exchange with the open lake.

Trace Contaminants

Heavy metals and trace organics are found in association with suspended particulates discharged from Mimico Creek, the Humber River, the Humber WPCP, and direct outfalls. Short-term impacts on water quality tend to be localized due to settling and dispersion of the particulate plumes in the open lake. Settling of contaminated organic material and silt/clay particles, however, has led to heavy contamination (i.e. parameters at concentrations greater than twice the MOE dredging guidelines) of bed sediments from the river mouth extending approximately 2 km offshore.

The long-term impacts of these particulate discharges are poorly understood and are currently under investigation as part of the In-place Pollutants and Toronto Waterfront studies.

Nutrient Enrichment

Phosphorus loadings from the Humber River, Mimico Creek, direct outfalls, and occasionally from the Humber WPCP, result in localized, highly variable zones, exceeding the provincial guideline for maintenance of nuisance-free conditions. As a result, nuisance growths of algae are common along the Etobicoke shoreline (where the rocky substrate provides ideal conditions for growth) and are an occasional problem at the Western Beaches.

Aquatic Life

There is a variety of freshwater aquatic life present in Humber Bay. This provides an angling opportunity for fisherman. As such,

there is a concern that contaminant pollution in the bay would restrict the consumption of sport fish. The "Guide to Eating Ontario Sport Fish" (MOE, 1985) identifies the presence of Rainbow smelt, Lake trout, White sucker and Rainbow trout. The Guide recommends limited consumption of Lake Trout larger than 45 cm in size and no restrictions on the consumption of the other fish. Any further degradation of water quality in Humber Bay would have adverse effects on the consumption of sport fish caught.

5.4 DISCUSSION

The water quality characterization presented in the previous sections has shown that the objectives for heavy metals, bacteria and certain nutrients are regularly exceeded and for several parameters are almost continually exceeded under both wet and dry conditions. As outlined in chapter 4, the Humber watershed can thus be considered to fall into the Policy 2 category, specifically, an area that does not meet the objectives and thus water quality should not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives.

The occurrence of pesticides and industrial organics, referred to as Hazardous Contaminants, is intermittent and appears inconclusive as to the source, however, an effect is being shown by the uptake in clam and fish samples. A further stress is being placed on the aquatic biota by the high levels of heavy metals. The level of stress induced by the high metals concentrations is difficult to infer. The PWQO's generally reflect long-term exposure or chronic toxicity. An acute toxicity level exists as well (Seto, 1985) for short term exposure, and is exceeded consistently under wet weather conditions for copper, and approached for lead.

The implication of the exceedence of the bacteria guideline is that body contact within the Humber Basin is restricted and also the loading to the lake may have an impact along the waterfront.

Reductions in bacterial, trace contaminant, and nutrient discharges from the Humber River (as the result of remedial actions in the respective watershed) can be expected to result in some improvement of conditions in Humber Bay. However, since the relative contributions from the Mimico Creek, Humber WPCP and direct outfalls are not well established, the degree of improvement cannot yet be predicted quantitatively.

The principal parameters modelled for this study included lead, zinc, copper, and fecal coliforms, parameters which are known to consistently exceed the PWQO's. Cadmium, another metal of concern, was not modelled due to limited data. Conclusions relating to cadmium have been made based on the simulated behaviour of the other metals and information derived from the literature.

Total phosphorus concentrations regularly exceeded the PWQO for maintenance of nuisance-free conditions, but observations of dissolved oxygen and aquatic growth did not support the hypothesis that nutrient enrichment was producing an impairment of the water quality in the Humber River. Nuisance aquatic growths however, occur within Humber Bay, and with the Humber River being a contributor to the water quality of the bay, efforts to reduce the phosphorus loads are warranted. Specific modelling of phosphorus was not considered a priority because of the lack of in-stream impacts and the large number of other sources contributing to the lake. Total phosphorus loads produced by both urban and rural sources will be reduced as a natural consequence of actions taken to reduce metal and bacterial contamination.

6. SOURCES OF CONTAMINATION

In order to address all the main contributors of direct discharges and associated pollutant loadings to the Humber River, a number of source identification projects were carried out. These projects were designed to characterize pollutant loadings according to the type of sewerage, weather conditions and land use type categories. They included the Dry Weather Outfall Study, the Combined Sewer Study, the Storm Sewer Studies and the Industrial Assessment Study.

6.1 URBAN BASEFLOW LOADINGS

Sewer Outfalls

A program of sewer outfall mapping and sampling was undertaken during the autumn of 1982 in the Humber River Basin within Metropolitan Toronto to identify which outfalls carry significant contamination to the Humber River under dry weather conditions (TAWMS, TR#1, 1983).

Of the 624 outfalls located in the study area, 366 (58%) were active or flowing under dry weather conditions; 239 (38%) were sampled. Not all active outfalls could be sampled because of insufficient discharge or difficult access. Eighty four (13%) outfalls were considered sufficiently contaminated to warrant intensive sampling.

A total of 68 outfalls were found to be the most significant outfalls contributing contaminants to the Humber River. Fifty two were identified for bacterial contamination and 28 for chemical contamination. Twelve outfalls had both bacteriological and chemical contamination.

Total outfall dry weather loadings were calculated for the chemical contaminants and are listed in Table 6.1. Certain study area reaches contributed the bulk of specific categories of chemical loadings.

TABLE 6.1 : AVERAGE DAILY DRY WEATHER STORM SEWER LOADS

Parameter	Total Outfall Loading (kg/day)
TKN	59
NH_3	21
NO_3	15
Total P	21
BOD	351
COD	1800
Phenol	0.3
SS	1681
Pb	1.5
Cu	0.4
Cr	3.6
Zn	12.3
Hg	0.1

Outfalls in two reaches, L & G (Figure 6.1), contributed the major loads of nutrients, oxygen demanding contaminants and metals. The most significant contribution of chemical contamination during the dry weather survey originated from industrial land use areas. Three priority outfalls were responsible for a major portion of the total dry weather load for many chemical contaminants.

Follow-up action has been initiated on identified outfalls by the respective municipalities. Several cross-connections between sanitary and storm sewers have been located and corrective action has been taken.

For reasons of poor accessibility, limited analytical resources or the nature of dry weather flow sources, too few samples could be analyzed to permit identificaton of all priority outfalls. These limitations also affected the calculation of the total loads to the Humber River. In addition, analytical results which reported data less than the analytical detection limits were not used in loading calculations. Consequently, additional loads exist for those outfalls discharging concentrations below the detection limit.

Baseflows from Two Pilot Urban Catchments

Figure 6.1 also shows the location of the two pilot catchments monitored as part of the storm sewer study.

Table 6.2 summarizes the results of monitoring baseflow from the two urban catchments. High concentrations of several pollutants, specifically dissolved solids and fecal coliform, were observed in the residential area. Baseflow concentrations for the industrial area were close to those for the residential area with the exception of increased nutrient concentrations. Comparing baseflow concentrations to the Metropolitan Toronto Sewer Use Bylaw shows violations from the industrial catchment for only particulate residue (suspended solids), Total Phosphorus and Phenolics. Table 6.2 also compares the estimated annual discharges for the pilot

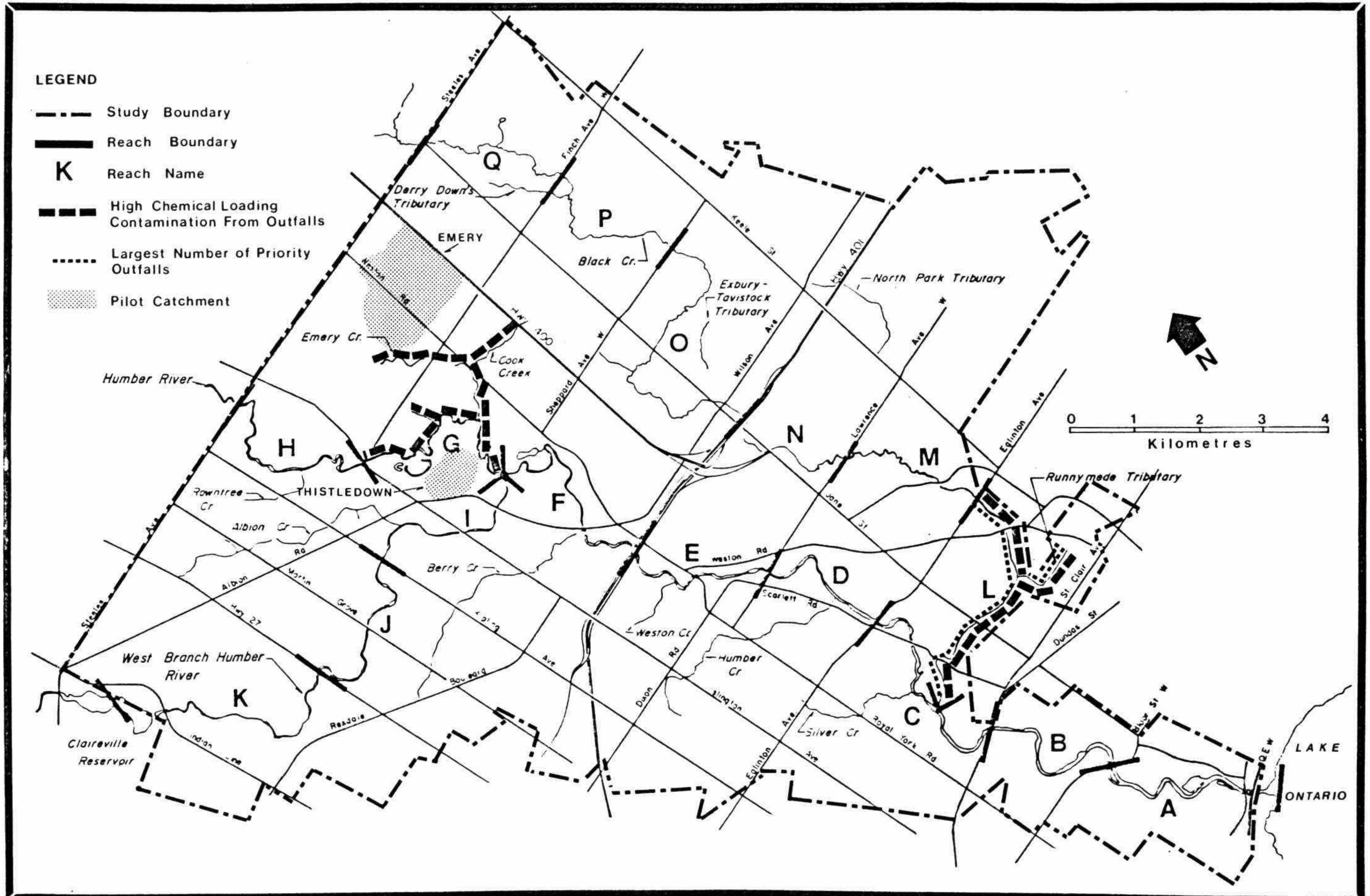


FIGURE 6.1 : HUMBER RIVER AND TRIBUTARY DRY WEATHER OUTFALL STUDY: STUDY AREA AND REACH BOUNDARIES

TABLE 6.2 : PILOT CATCHMENT BASEFLOWS

Parameter	Median concentrations				Estimated Annual Discharge		
	Units	Thistledown*	Emery**	Bylaw+	Units	Thistledown	Emery
Total residue	mg/l	979	554	-	kg/ha	2230	1520
Filterable residue	mg/l	973	454	-	-	-	-
Particulate residue	mg/l	<5	43	15	-	-	-
Total Phosphorus	mg/l	0.09	0.73	1.0	g/ha	206	2000
TKN	mg/l	0.9	2.4	-	g/ha	2060	6580
Phenolics	mg/l	<1.5	2.0	0.02	mg/ha	<3400	5490
Cod	mg/l	22	108	-	kg/ha	50	296
Fecal Coliform	#/100ml	33000	7000	-	10^9 org/ha	754	192
Fecal Strep	#/100ml	2300	8800	-	-	-	-
Chromium	mg/l	<0.06	0.42	1.0	g/ha	<140	1150
Copper	mg/l	0.02	0.045	1.0	g/ha	<90	<100
Lead	mg/l	<0.04	<0.04	1.0	g/ha	<90	<100
Zinc	mg/l	0.04	0.18	-	g/ha	91	<5.5

* Thistledown - 85% residential, 15% commercial Landuse

** Emery - Industrial Landuse

+ Metropolitan Toronto Sewer Use Bylaw

catchments. The unit area yields for many pollutants were much greater for the industrial area.

6.2 URBAN STORMWATER LOADINGS

In general stormwater pollution from an urban area is the result of complex processes which are influenced by catchment characteristics, hydrologic conditions and other external influences. A simple illustration of the processes is shown in Figure 6.2.

The sources of runoff and the relative magnitudes of the volumes from the sources are illustrated in Figure 6.3. In both the residential and the industrial catchments, the largest sources were streets and rooftops connected to sewers (Gartner Lee, 1984). Pervious surfaces such as lawns contributed little runoff volume except in infrequent heavy storms.

Dust and dirt on paved surfaces was a major source of stormwater pollution. Accumulation increases steadily as the dry weather interval lengthens. The industrial catchment had higher accumulation rates than the residential catchment.

The amount of a pollutant washed off by stormwater runoff depended on the runoff volume and the type of source area. For example, Figure 6.4 shows the amount of total solids yielded from different source areas for different runoff volumes. Total solids are of particular interest to the study, because several contaminants tend to associate with total solids. In the residential catchment, paved areas and connected rooftops were the main contributors of total solids in small rains (below 5mm). Front yards and lawns, however, contributed a significant amount in heavier rains. In the industrial catchment, the paved areas and connected rooftops were the main contributors in all rain magnitudes.

Estimated annual stormwater pollutant loads discharged at the outfalls of the pilot catchments are shown in Table 6.3. It is

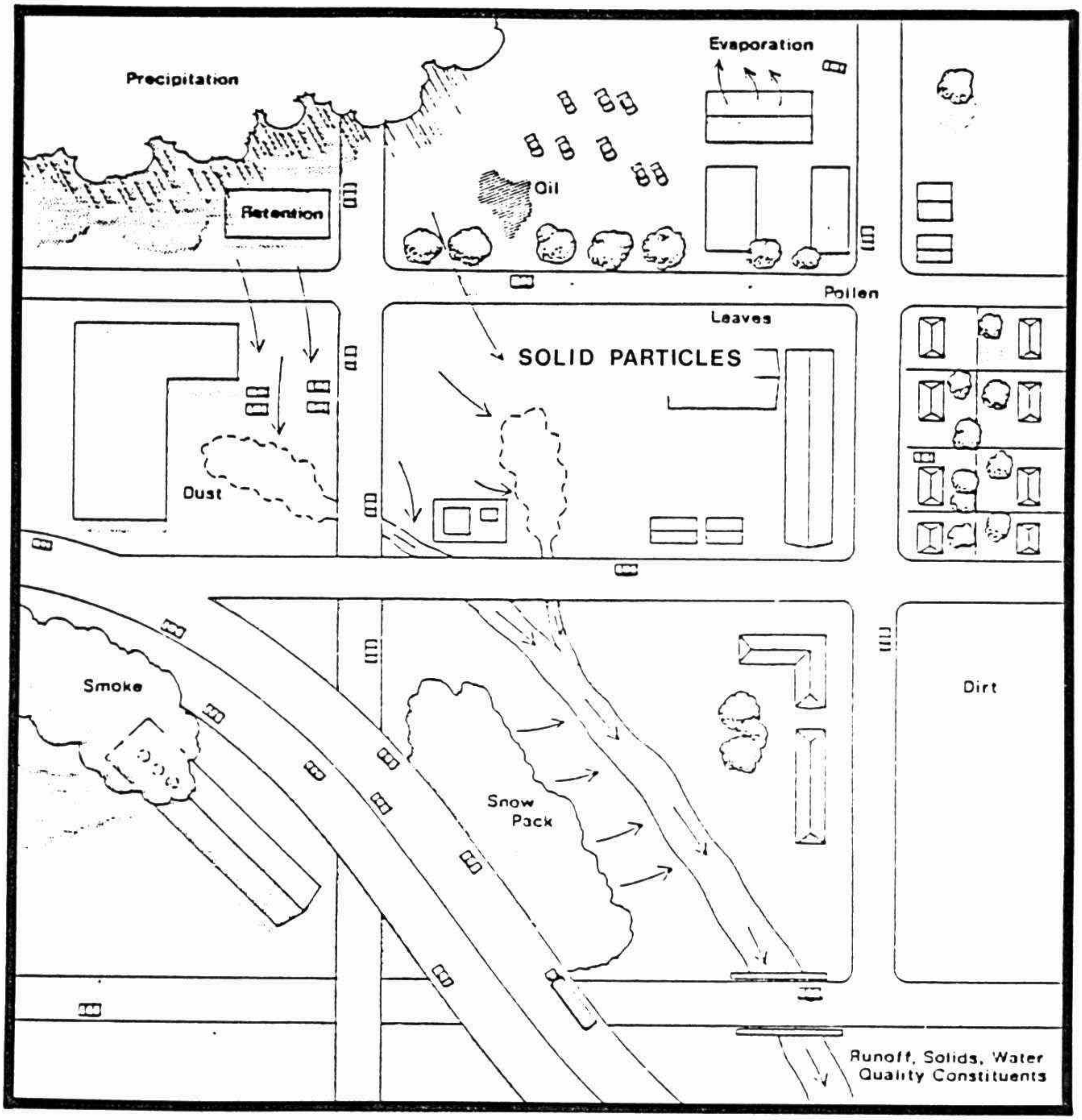
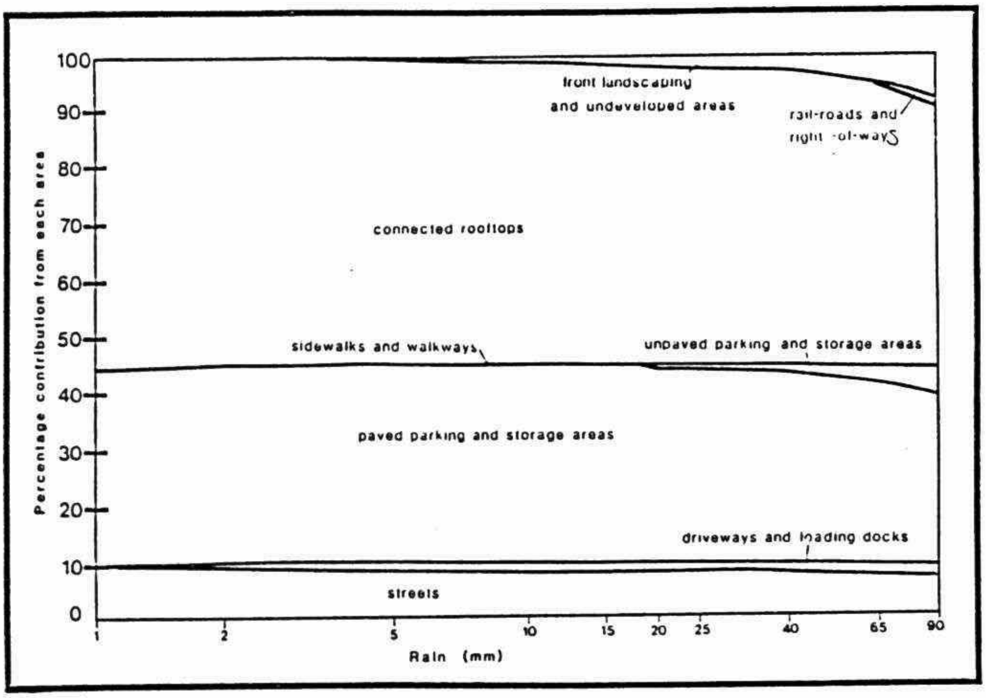
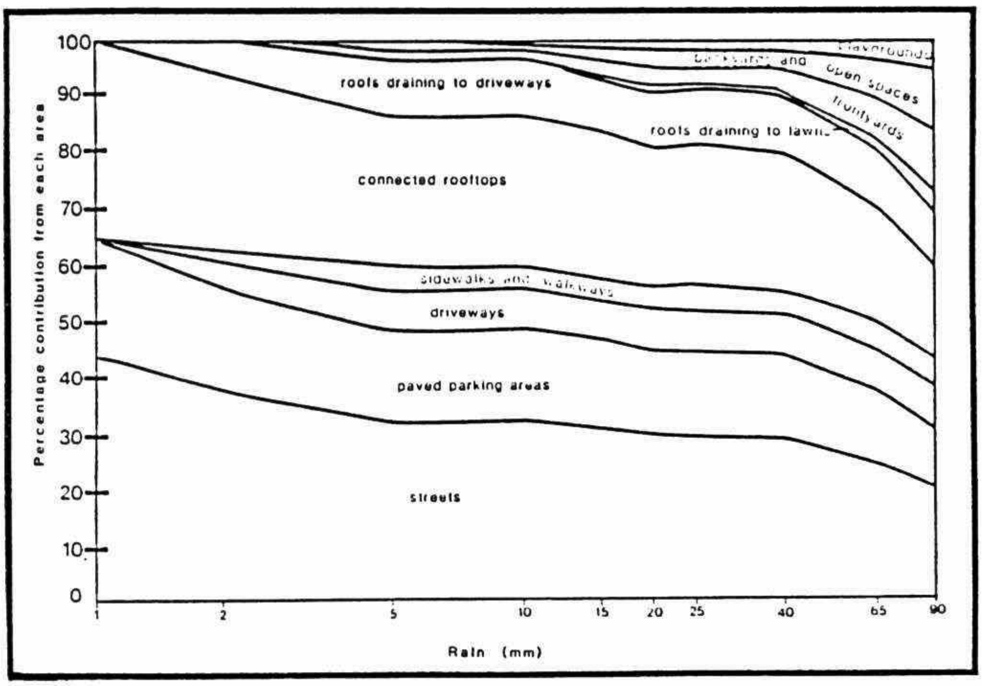


FIGURE 6.2 : URBAN PROCESSES

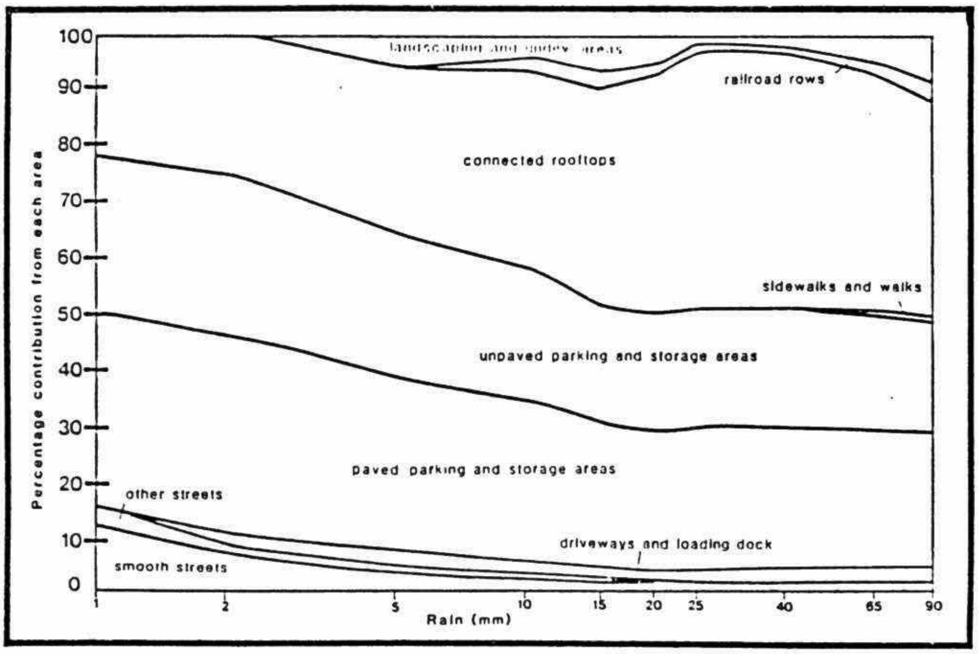


INDUSTRIAL CATCHMENT

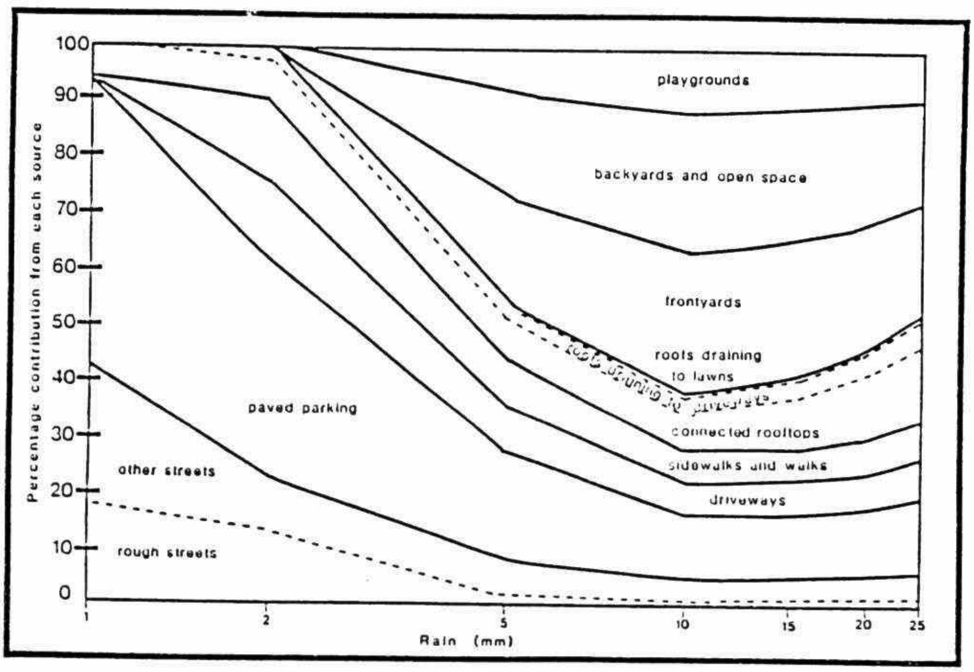


RESIDENTIAL CATCHMENT

FIGURE 6.3 : SOURCES AND VOLUMES OF RUNOFFS



INDUSTRIAL



RESIDENTIAL

FIGURE 6.4 : SOURCES OF SOLIDS

worth noting that for approximately half of the pollutants, the baseflow loadings were higher than the runoff loadings.

6.3 ANALYSIS OF COMBINED SEWER OVERFLOW LOADINGS

The combined sewer system described in Chapter 3 was monitored in 1983 and analysed in detail (TAWMS, TR# 7, 1986). The results are summarized below:

- o The dry weather flow quantities and qualities were within normal ranges of municipal sewage

- o Dry weather infiltration was 40% of dry weather flow. This rate was not abnormal. The corresponding monitored result for the separate sewer area was 22%.

- o In wet weather, the combined sewer regulators overflowed during storms with more than 4 mm precipitation. The smallest storm in which the exisiting CSO detention tank was filled had 8 mm precipitation.

- o The qualities of the combined sewage, as shown in Table 6.4, were not abnormal.

Combined sewer overflow analysis was carried out using model simulation. The simulation period was April to October, which was believed to be the season in which CSO is most predominant. The precipitation data in April-October, 1979 were used in the analysis. They were found to be representative of historical average precipitation conditions.

The simulation results indicated that under existing development and sewerage conditions, the regulators overflowed in 26 of the 64 rain events in the season. The estimated total seasonal CSO volumes and pollutant loads are also shown in Table 6.4.

TABLE 6.3 : PILOT CATCHMENT ESTIMATED ANNUAL POLLUTANT DISCHARGES

Constituent	Units	THISTLEDOWN (Residential)			EMERY (Industrial)		
		Base-Flow	Storm-Water	Total	Base-Flow	Storm-Water	Total
Total Solids	kg/ha	2230	297	2530	1520	821	2340
Total Phos.	g/ha	206	352	558	2000	1630	3630
TKN	g/ha	2060	3410	5470	6580	4160	10700
Phenolics	mg/ha	<3400	1510	1510-4910	5490	9870	15400
COD	kg/ha	50	62	112	296	212	508
Chromium	g/ha	<140	25	25-165	1150	730	1880
Copper	g/ha	46	36	82	123	144	267
Lead	g/ha	<90	50	50-140	<100	210	210-310
Zinc	g/ha	91	90	181	494	530	1020
Fecal Coliforms	10^9 org/ha	754	580	1330	192	925	1120

TABLE 6.4 : COMBINED SEWAGE QUALITY AND LOAD

Parameter	Flow-weighted Avg. Conc. (mg/l)	Total Seasonal Loads (kg)	
		Overflow*	Detained by Tank
Volume (m^3)	-	334,000	102,000
Suspended Solids	196.	63,000	16,000
BOD_5	55	16,000	5,000
Total Phosphorus	1.96	690	210
Filtered Phosphorus	0.44	230	72
Cadmium	0.006	2.6	0.8
Copper	0.119	41	13
Lead	0.182	65	20
Zinc	0.300	112	35
Fecal Coliforms	1.65×10^6 org/100ml	-	-

* includes overflow from existing tank

The overflow volume is 20% and the detained volume is 8% of the sewage yielded by the combined sewer area in the 26 storms. CSO fecal coliform loads in a single storm ranged from 80,000 billion to 670,000 billion organisms.

To eliminate CSO completely in the season will involve containment of the above mentioned volume and pollutant loads. The volume, if intercepted and treated at the Humber WPCP, will increase the WPCP seasonal treatment load by 0.5%. The Humber WPCP utilization data are summarized in Table 6.5.

Hazardous Contaminants Study

Two additional pilot catchments in the cities of York and North York were sampled in the summer of 1983 for Hazardous Contaminants (HC) in their dry weather sewage. The data were utilized for calibrating the HAZPRED computer simulation model being developed for predicting incidences and loads of hazardous contaminants in sanitary and stormwater runoff (TAWMS, TR# 5, 1984). Observed pollutant concentrations in sanitary sewage are presented in Table 6.6.

6.4 OTHER URBAN SOURCES

In addition to contaminant input to the stream from the sewerage system, which tends to be well defined, additional sources exist that can be intermittent and difficult to detect. These other urban sources consist of landfill leachate, snow dump sites, atmospheric fallout and accidental spills.

Statistics generated from the data compiled by MOE on intermediate and major spills for the period 1979 to mid 1984 show that there were 46 spills in the Humber River basin with the majority originating from industrial sources. Other sources include

TABLE 6.5 : HUMBER WATER POLLUTION CONTROL PLANT UTILIZATION

	Combined sewer area	Sanitary sewer area	Both areas
WPCP peak primary treatment capacity (m^3/s)	-	-	11.8
Peak flow to WPCP (m^3/s)	2.43	7.37	9.8
Peak flow to WPCP per person (m^3/person/s)	0.0000298	0.0000164	-
Total seasonal volume treated* (m^3)	9,150,000	70,560,000	-
Volume treated per person per day* (m^3/person/day)	0.526	0.735	-

* includes dry and wet-weather flow and flow returned from tank

TABLE 6.6 : OBSERVED AVERAGE HAZARDOUS CONTAMINANT CONCENTRATIONS IN SANITARY SEWAGE

Group/Pollutant	North York Average Observed Concentration (ug/l)	York Average Observed Concentration (ug/l)
Purgeable		
Benzene	2.4	2.3
Chloroform	47	7.1
1,1 Dichloroethylene	17	ND
Dichloromethane	207	264
Ethyl Benzene	82	398
Tetrachloroethylene	13	<3.0
Toluene	447	120
1,1,1 Trichloroethane	15.5	<3.0
Trichloroethylene	83	ND
Extractable-Acid		
2,4 Dimethyl Phenol	13	<2.5
Phenol	8.2	<1.6
Extractable-Base Neutral		
Bis(2-Ethyl Hexyl) Phthalate	9.1	21
Butyl Benzyl Phthalate	0.9	7.9
Di-n Butyl Phthalate	22	6.4
Di-n Octyl Phthalate	ND	<1.5
Dichlorobenzene	6.8	4.2
Napthalene	8.7	2.7
Phenanthrene	0.6	1.4
Metals and CN-		
Cadmium	1620	5.8
Chromium	2844	47
Copper	228	118
Lead	153	121
Mercury	0.32	0.24
Nickel	49.8	1.2
Zinc	7655	224
Total CN^-	2982	12

ND = Not Detectable

transportation corridors, gas stations and residential oil spills. In addition, spills were detected during routine field work by MOE staff (Table 6.7 summarizes this information), on eight occasions out of 17 visits to the watershed during this period. The type of contaminants input to the stream generally fall into the category of hazardous contaminants.

During the winter of 1984-85 three snow disposal sites were operated in the Humber River urban watershed and were found to be in compliance with MOE guidelines (MOE, 1984) which generally deal with site selection. Water quality monitoring at one of the sites showed no appreciable difference between the quality of the snow dump meltwater and the receiving water, Black Creek.

Atmospheric fallout is a pollutant source which contributes to the accumulation of solids. Deposition occurs when aerosols are deposited to the ground by fallout or by precipitation. Concentrations and deposition rates are generally a function of human activities, urban/industrial activities, air currents, and seasonal precipitation patterns. The largest contribution of heavy metals from the atmosphere is in the form of dry deposition which is several times greater than bulk (dry fallout, rainfall, and snowfall) and wet precipitation samples.

Landfill sites within the Humber River basin have been identified from information obtained from the municipalities. No direct sampling has been performed to date, however, the source identification and receiving water quality studies have not indicated any potential problems.

6.5 RURAL SOURCES

As part of the Upper Humber River Water Quality Study (TAWMS, TR# 8, 1986), sediment loading from rural overland sources was mapped and a field inventory of potential pollution sources was conducted. Sites of streambank erosion, areas of livestock access to the water course and point source inflows were noted during the inventory.

TABLE 6.7 : SPILLS OBSERVED BY MOE & U of T STAFF IN THE HUMBER RIVER AND BLACK CREEK FOR THE PERIOD APRIL, 1985 TO AUGUST, 1985

Date	Reported By	Location	Description of Spill	Response	Comments
Apr 24/85	MOE Staff	Maybank Ave. & Weston Road Source appears to be either outfall #125 or outfall #127. These outfalls drain into Runnymede Tributary which flows into Black Creek.	Brown - creamy substance in sewer pipe. After entering the stream it changed into a foaming white substance.	Contacted Metro Works who arranged for samples to be taken.	Charges have been laid by Metro
Jul 19/85	University of Toronto staff	Humber River downstream of Emery Creek	Grayish murky substance in Emery Creek	Contacted Central Region, MOE. Requested samples to be taken.	
Jul 25/85	MOE Staff	Storm sewer #200 located approximately 75m downstream of Albion Road on West Humber River.	Oil in storm water. Oil was well contained in the sewer by debris on the sewer gate. However, the first storm would cause the oil to be flushed into the West Humber River.	Contacted Metro Works, Etobicoke and Central Region, MOE. Requested clean-up.	
Jul 30/85	MOE Staff	Emery Creek	Oily film on water.	Contacted Central Region, MOE	
Aug 2/85	MOE Staff	Emery Creek, Finch & Weston Rd.	Red substance in the water.	Contacted Central Region, MOE	
Aug 22/85	MOE and U of T Staff	Small outfall on Emery Creek Outfall # 264	White creamy substance	U of T collected samples	High bacteria counts detected
Aug 22/85	MOE and U of T Staff	2 outfalls on Emery Creek Outfall #502 - Outfall #504 -	 Green & grayish colour substance in water Pink & redish substance in water	Contacted Central Region, MOE Requested samples to be taken	High levels of heavy metals detected in outfall 502

Note: Outfall numbers refered to above from outfall survey (TAWMS, TR# 1, 1983).

Overland Sediment Delivery

Soil loss mapping of the upper Humber revealed that the most significant overland sediment delivery potential is found in sub-catchments in the central and northern portions of the Humber and East Humber River basins. In the northern areas, the high delivery potential results largely from the undulating topography of the Oak Ridges Moraine. In the central areas, the combination of slightly rolling topography and row crop agriculture account for the high delivery potential.

Streambank Erosion

The total area of exposed, erosive streambank has been determined for each sub-catchment in the upper Humber. The West Humber has the greatest erosive area per unit watercourse length at 1486 m^2/km, followed by the East Humber at 1281 m^2/km then by the Humber at 949 m^2/km.

Livestock Access

Livestock access can contribute to water quality deterioration in dry weather as well as wet. On the upper Humber River livestock have greatest access to the river in some of the more southerly sub-catchments. Livestock access might be contributing to the pronounced streambank erosion and increased suspended solids and total phosphorus loadings observed in these areas.

On the East Humber River, livestock access is significant only in the sub-catchment upstream from Kleinburg. Livestock have access to the river in all West Humber sub-catchments. This might account for the high fecal coliform counts determined there for wet weather conditions.

Point Sources

In the upper reaches of the Humber River, most of the inflows are natural. There are, however, numerous man-made inflows, primarily from pastoral, residential, or small commercial lands.

Storm sewers and other man-made sources in Bolton, Woodbridge, King City, and Oak Ridges discharge into the Humber system. There are also some storm sewer outfalls in Caledon East that discharge into Centreville Creek.

The water pollution control plants in Bolton and Kleinburg have outfalls to the Humber River. After 1985, the Bolton plant will cease operations and sanitary sewage from Bolton will be directed south to Brampton through a trunk system. The Kleinberg plant is expected to continue operation and a plant expansion is anticipated in the future.

6.6 RELATIVE SUB-WATERSHED CONTRIBUTIONS

Water quality data were collected during the 1982-83 TAWMS program (TAWMS, TR# 4, 1984) for dry weather, rainfall-runoff events, and spring runoff, at stations within the urban Humber basin. Contaminant contributions were computed for the watershed sub-catchments representing major divisions within the basin. Net dry weather flux (net amount of contaminant contributed by a sub-catchment per unit time per unit area) and net wet event and spring runoff area loadings (net amount of contaminant contributed per unit area during the event) are shown for each sub-catchment in Table 6.8.

The net loadings provided in Table 6.8 indicate the relative importance of the various portions of the Humber River basin under different hydrologic regimes. It is apparent that Black Creek is a major source of all contaminants (metal and bacteria) on a unit area

TABLE 6.8 : DRY WEATHER FLUXES AND WET EVENT AND SPRING RUNOFF LOADINGS PER UNIT SUBCATCHMENT AREA

Parameter/Event	Upper Humber ($537\ km^2$)	West Humber ($221\ km^2$)	Upper Black Creek ($50.4\ km^2$)	Lower Black Creek ($14.7\ km^2$*)	Mid Humber ($41.4\ km^2$)	Lower Humber ($27.2\ km^2$)
Runoff						
- dry (mm/d)	0.24	0.41	0.25	0.18	0.83	0.56
- wet 1 (mm)	0.16	0.38	0.96	2.5	3.8	-
- wet 2 (mm)	12	19	28	39	-	-
- spring (mm)	67	62	73	78	73	70
Cadmium						
- dry (g/(km^2,d))	0.073	0.13	0.39	-	-0.092	-0.44
- wet 1 (g/km^2)	0.047	0.11	0.94	4.7	0.62	-
- wet 2 (g/km^2)	3.6	5.6	16	9.1	-	-
- spring (g/km^2)	55	40	60	187	-126	403
Copper						
- dry (g/(km^2,d))	1.9	3.6	3.1	9.2	-7.3	12
- wet 1 (g/km^2)	1.2	3.8	30	180	31	-
- wet 2 (g/km^2)	171	249	440	663	-	-
- spring (g/km^2)	1460	1030	2110	3370	-1070	5500
Lead						
- dry (g/(km^2,d))	0.84	1.8	2.4	-1.8	1.5	-5.1
- wet 1 (g/km^2)	0.57	5.7	106	464	26	-
- wet 2 (g/km^2)	123	236	1170	1700	-	-
- spring (g/km^2)	771	1010	4480	8510	3040	13500
Zinc						
- dry (g/(km^2,d))	3.7	0.67	4.6	28	-30	6.7
- wet 1 (g/km^2)	4.7	5.5	179	650	22	-
- wet 2 (g/km^2)	311	593	1750	1830	-	-
- spring (g/km^2)	1760	1740	6390	11200	6690	12600
Fecal Coliforms						
- dry (billion/(km^2,d))	0.13	0.42	2.9	13	0.063	15
- wet 1 (billion/km^2)	1.7	10	30	17200	77	-
- wet 2 (billion/km^2)	37	93	167	1500	-	-
- spring (billion/km^2)	135	218	547	18100	-718	5080

* Does not include 9.5 km^2 from combined sewer overflow
- Indicates value suspect owing to sampling or analytical uncertainties.

basis. Under dry weather conditions, Black Creek has the highest fluxes of cadmium, lead, and zinc and is second to the lower Humber in terms of copper and fecal coliforms. In wet weather, Black Creek has the highest area loadings of all contaminants. During spring runoff the lower Humber has the highest area loadings of metals, probably as a result of resuspension of accumulated sediments. Black Creek has the second highest area loadings of metals during the spring and is dominant in terms of fecal coliforms.

6.7 SIMULATED EXISTING CONDITIONS

Environmental processes can often be represented by mathematical expressions or equations developed in research studies. A collection of equations that describes the behaviour of an environmental system such as a watershed is a mathematical "model" of the system. The Systems Model Procedure was developed utilizing two methods to integrate and process data for the entire system.

The Hydrological Simulation Program - Fortran (HSP-F) was used to simulate hydrology and pollution by metals. Each of the metals was assumed to behave as a conservative substance for the purposes of modelling. A simplified mass balance technique, incorporating die-off, was used to simulate bacterial contamination.

The relative contributions of the Humber sub-catchments under various flow conditions is useful in identifying the areas where pollution control efforts will have the greatest effect. In order to integrate the relative impacts of wet and dry weather loadings, and to account for size of the sub-catchment, it is necessary to examine loadings on an annual basis. Insufficient data was available to calculate annual loads directly. Computer simulation, using a model calibrated to observed data, was therefore employed to extend the data base to an annual period.

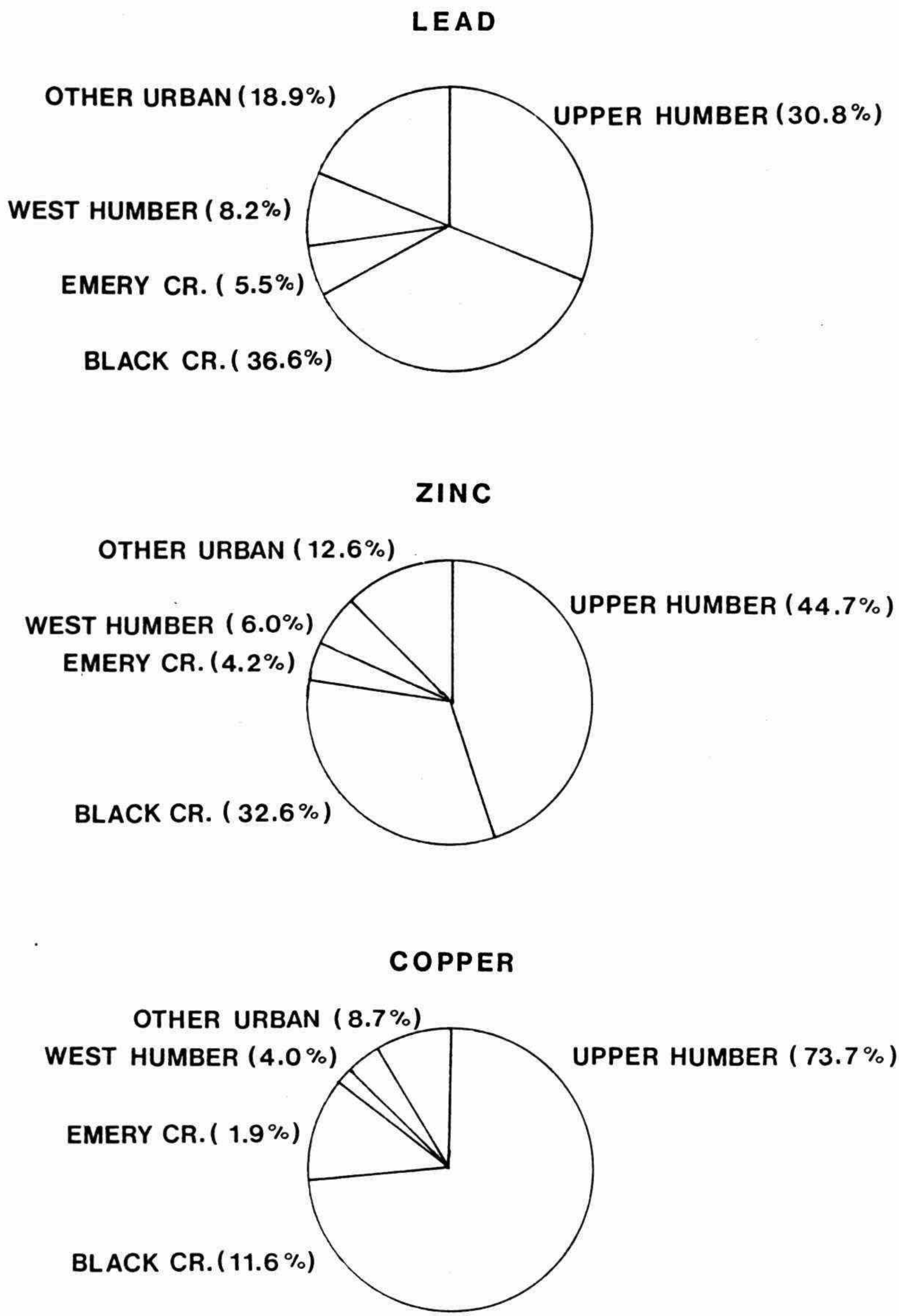


FIGURE 6.5: HUMBER RIVER LOADING SOURCES

The relative importance of rural areas and major urban tributaries as contributors of annual loadings of lead, zinc and copper is shown in Figure 6.5. The contribution of non-urban areas amount to 31% and 45% of the total annual loads of lead and zinc respectively. In addition, statistical analyses suggest a much higher contribution of copper (74%) from non-urban areas. This latter contribution must be considered tenuous because of the limited data used in statistical analysis. There can be little doubt however that the non-urban portion of the Humber is a significant source of copper because observed concentrations of this parameter regularly exceeded the PWQO at Steeles Avenue (TAWMS, TR# 4, 1984). Within the urban portion of the Humber, Black Creek is the most important source of metal contamination, producing 37%, 33% and 12% of the total annual loads of lead, zinc and copper, respectively. Emery Creek and the West Humber below Claireville are also siginificant sources of metals.

The effect of this distribution of sources is illustrated in Figure 6.6. Progressing downsteam, a relatively constant increase in loading is observed, except for the abrupt increases at Emery Creek, the West Humber and Black Creek. The simulation suggests a relative homogeneity of pollutant generation throughout most of the urban Humber. Black Creek is a major source of metal contamination, but its location near to the mouth of the Humber limits its impact on much of the river. The West Humber is also a major loading source, although a significant portion of the load originates upstream of the Claireville Reservoir. Emery Creek is a major source on a unit area basis, but its small tributary area limits its impact on downstream reaches.

The loads produced by individual sewersheds within the urban Humber are influenced by contributing area, mix of land use, and degree of imperviousness. Figure 6.7 indicates the total loads and the unit loads for each metal on a sewershed basis. The two Black Creek sewersheds dominate these Figures, producing 53% of the lead, 59% of the zinc and 44% of the copper attributable to all urban sources. High unit loads are noteable on Emery Creek, two of the West Humber sewersheds, and the industrial areas near Highway 401.

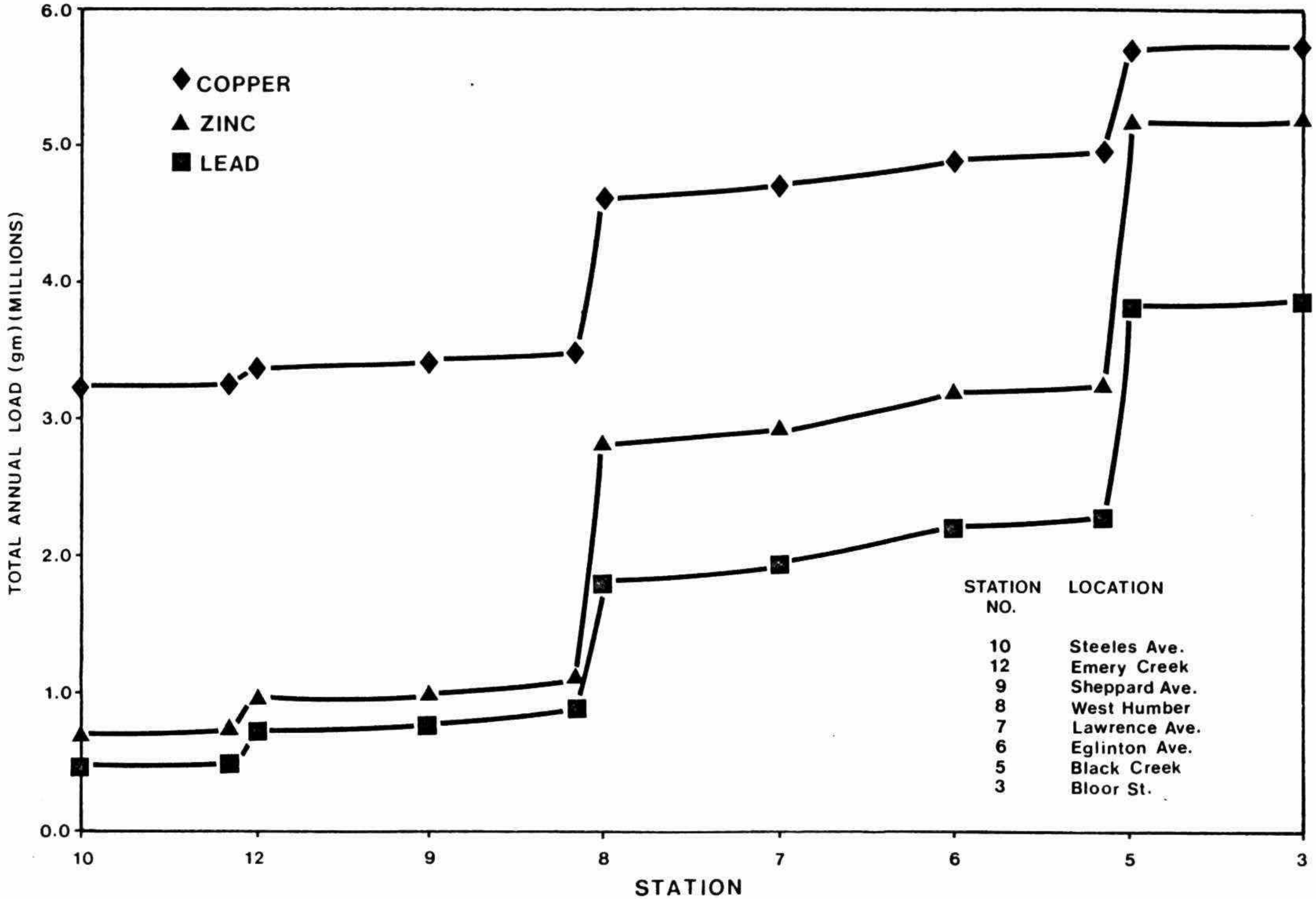


FIGURE 6.6: HUMBER RIVER TOTAL ANNUAL LOADS - EXISTING CONDITION

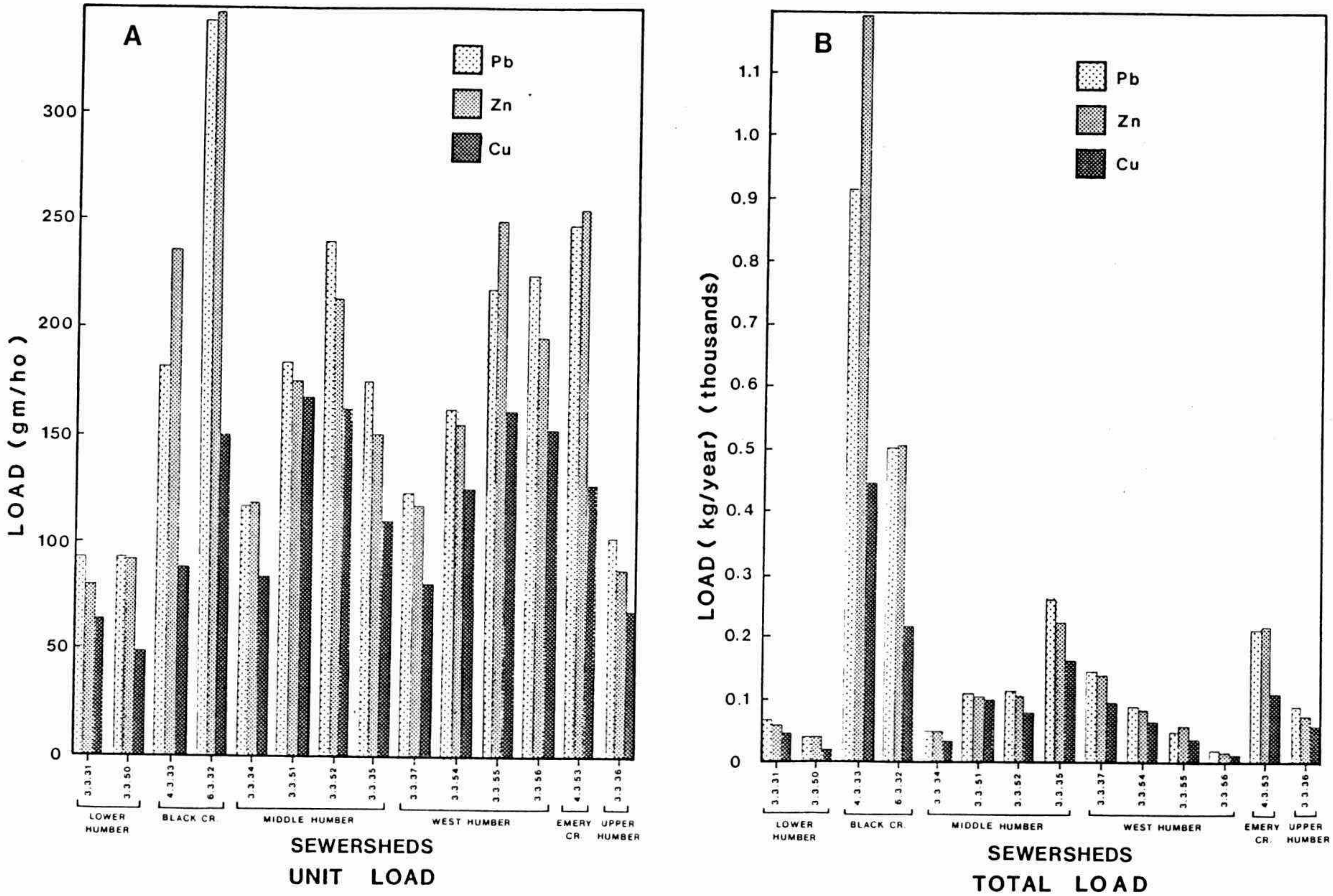
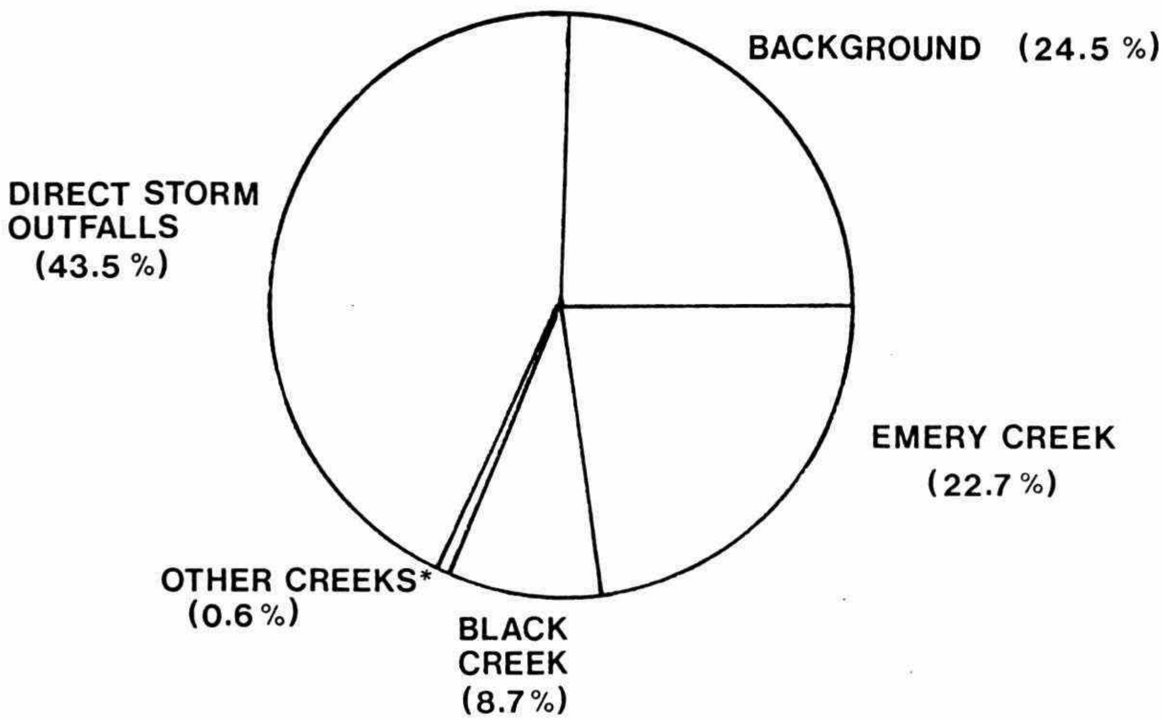


FIGURE 6.7 : HUMBER RIVER METAL LOADS

Annual loads of bacteria were not calculated in this study. Instead steady-state simulations were generated to demonstrate the relative sub-watershed contributions of FC bacteria under existing conditions. Figure 6.8 indicates the distribution during dry weather. The upper Humber contributes about 25% of the dry weather load. Emery Creek and Black Creek are significant dry weather sources, producing about 30% of the load. The contribution by other tributaries is minor. The large contribution by storm sewers discharging directly into the Humber River is particularly significant. These direct discharges will be difficult to mitigate through on-site treatment. The large load percentage associated with direct storm sewer outfalls indicates the importance of the current program to trace illegal connections.

Under wet weather conditions the distribution of loading shifts more strongly towards urban sources. The upper Humber becomes a comparatively minor source, primarily because of the large increase in urban loads. As in dry weather, storm sewers discharging directly into the Humber River are a major source. Tributary loads of FC bacteria are substantial. As in the case of dry weather loads, Emery Creek and Black Creek are major tributaries of concern. Black Creek is of particular concern because the combined sewer overflow points and the creek's location relative to the Lake.



*Other Creeks includes the West Humber River

FIGURE 6.8 : DRY WEATHER FECAL COLIFORM LOADING SOURCES

7. EVALUATION AND SCREENING OF CONTROL OPTIONS

Technical measures with the aim of improving water quality or reducing flooding can range from simple public education schemes to extensive structural works, and are referred to as control options. Control options which address the goals of the study, upgrading water quality and flood reduction, are generally well defined within the literature, and cover a broad range of point and diffuse source control for both urban and rural areas. The surface water quality characterization and identification of sources of contamination lead to the formulation of detailed options specific to the Humber River watershed.

This chapter introduces the options and outlines the results of the screening exercise which recommends either not including an option, including an option in the management plan or that the option be further evaluated as part of the systems modelling procedure, the results of which are presented in Chapter 8.

7.1 SCREENING

A prescreening exercise was performed to qualitatively evaluate all the options. The aim was not to rank projects or to identify the best but rather to eliminate the worst. The evaluation criteria described in Chapter 4 were used to screen and evaluate the options. These criteria may be expanded to include the additional criteria of technical feasibility (is the land available, or do other constraints preclude the project?) and inferiority (is the water quality impact minimal or the cost high relative to other projects?).

The prescreening in general consisted of a literature review to determine effectiveness and costs, and an examination of existing programs. The results of the prescreening are shown in Table 7.1 and in general present options that are considered feasible. Detailed definitions and screening results are presented in Appendix A.

TABLE 7.1 : CONTROL OPTION SUMMARY

Category	Control Options
I. Hazardous Contaminant Management	Disposal facilities/Public education re: handling of Hazardous Contaminants in the home. Hazardous Contaminants spills management program.
II. New Municipal Bylaws and Operations	Dog litter control programs. Temporary/Permanent snow disposal facilities.
III. Conservation Authority Programs	Sediment Control for urban construction. Dredging behind weirs and in the lower Humber. Streambank erosion control. Additional flow augmentation from reservoirs. Bird control measures.
IV. Direct Abatement and Bylaw Enforcement	Additional enforcement of existing plumbing bylaws. Additional enforcement of existing sewer use bylaws. Landfill leachate controls in the flood plain.

TABLE 7.1 (cont'd)

V. Urban Source Controls	Disconnect roof leaders discharging to sanitary sewers. Reduce erodibility of surfaces. Catchbasin cleaning. Enhanced street sweeping.
VI. Structural Urban Source Controls	Stormwater detention ponds. Combined Sewer Overflow (CSO) interception for treatment at the Humber WPCP. Direct treatment of CSO. Flow control at local combined sewers. Sewer separations. Flow disinfection
VII. Rural Diffuse Source Controls	Erosion and sediment control - agricultural. Livestock access control. Manure storage and spreading methods. Illegal connections to drainage tile. Septic tank malfunctions. Control storm runoff on new developments. Erosion and sediment control on construction sites.

7.2 EVALUATION

Summarizing the information contained in Table 7.1 and that in Appendix A, shows that the Hazardous Contaminant Management options (group I) are recommended for inclusion in the management plan. A survey of the municipalities has shown that spills of hazardous materials occur on a regular basis. These spills can have both short and long term impacts. Both control options are relatively inexpensive to implement and will increase the public and commercial awareness of the problem which will aid in the control of hazardous contaminants.

The New Municipal Bylaws and Operations options (group II) are also recommended for the management plan and are low-cost and easily implementable options. While snow disposal facilities were found to be in compliance with MOE guidelines, they should continue to be monitored to ensure continued compliance. A continued effort is required to ensure that dog litter control measures will be effective in reducing the input of dog feces to receiving streams.

An important aspect of the Group I and II options is that they require participation by the public directly. Residential sources are a part of the problem on the Humber River and it is essential that an improved awareness be developed by the public. In this regard, programs such as litter control, which may have only minimal impacts on water quality, should be pursued in order to increase direct public involvement.

Of the five options from the Conservation Authority Programs (group III), two are recommended, sediment control for urban construction and stream bank erosion control. Increased sediment concentrations reduce water quality and lead to habitat deterioration. Both options represent effective controls for potential sources to the stream. The three options not recommended, were shown to be not technically feasible, in that the water quality impact would be minimal.

The Direct Abatement and Bylaw Enforcement options (group IV) are currently in place and will require specific action as problems are identified. The dry weather outfall survey (TAWMS, TR# 1, 1983) has identified significant contaminant inputs through the sewerage system, thus the increased by law enforcement options should receive increased emphasis during abatement activities. Investigations of known landfill sites have indicated no water quality problems attributable to leachate. Investigation of other older landfills is warranted.

The Urban Source Control options (group V) represent best management practices for urban source control. The reduction of erodibility of surfaces is recommended as a relatively low-cost option that can aid in the reduction of the delivery of sediment to the stream. The remaining options can have direct, measurable in-stream impacts, and are dealt with in more detail in Chapter 8.

The Structural Urban Source Control options (group VI) will form the core of the management plan and require detailed systems analysis to evaluate in-stream impacts. The results of the analysis are presented in Chapter 8.

The Rural Diffuse Source Control options (group VII) were dealt with to some degree in the Upper Humber River Water Quality Study (TAWMS, TR# 8, 1986). These options represent low-cost controls that should be implemented to deal with degraded water quality existing upstream from the northern boundary of Metropolitan Toronto.

7.3 CONTROL OPTION FORMULATION AND TESTING

Options which physically effect the build-up, transport or release of pollutants, can be evaluated quantitatively. It is possible to assess the pollutant reduction effectiveness of these options and to provide additional information which will form a basis for selection or rejection of the control.

Those options which may be evaluated quantitatively, in terms of in-stream impacts, include:

1. Elimination of Combined Sewer Overflow (CSO Control)
2. Retention Ponds in Industrial Areas (Industrial Control)
3. Increased Street Sweeping
4. Catchbasin Cleaning
5. Disconnection of Residential Roof Leaders
6. Retention Ponds in Residential Areas (Residential Control)
7. Elimination of Dry Weather Contamination from Selected Priority Outfalls
8. Disinfection

The primary pollution concerns on the Humber River relate to heavy metals (eg. lead, zinc, copper and cadmium) and bacteria. Each of the options listed above will exhibit differing degrees of effectiveness for each of the contaminants. In general, however, the criteria for judging performance of the options will be similar for the metals as a group, but not for bacteria.

A brief description of each option is provided below:

<u>Elimination of Combined Sewer Overflow</u>

This option represented complete elimination of the CSO on Black Creek. While total elimination may not be practical, studies have indicated the feasibility of reducing overflows to approximately once per year through the use of CSO detention tanks (TAWMS, TR# 7, 1986). The CSO option tested is not directly equivalent to other means of CSO control such as sewer separation. Sewer separation would be expected to be less effective than the option tested because metals contained in storm water would continue to be released to Black Creek during runoff events.

<u>Retention Ponds in Industrial Areas</u>

This option represented the use of stormwater retention ponds to reduce pollutant loads from industrial, commercial and highway land

use throughout the Humber River watershed. Simulation was based on a fixed percentage reduction (variable for each contaminant) of the pollutant load from the applicable portion of each sewershed. This method of simulation is most representative of a system of retention basins at the outlet of each industrial/commercial catchment. The simulation does not result in any reduction of pollutant load from residential or rural areas. It was assumed the ponds would be sized such that the surface area would represent 1% of the contributing areas.

Streetsweeping and Catchbasin Cleaning

The separate control options of streetsweeping (all streets: 3 times per week) and catchbasin cleaning (each catchbasin : twice per year) were combined for this simulation. The option was applied to all urban sewersheds without differentiating between industrial/ commercial and residential land use. As in the case of industrial retention ponds, the simulation methodology involved a percentage reduction of pollutant load, which varied for each contaminant. In considering this option it is assumed the cleaning spoils will be disposed of in a manner which will prevent runoff or leaching of contaminants into the river. If disposal sites are improperly designed or maintained, cleaning practices simply convert a diffuse source problem into a point source.

Roof Leader Disconnection

This option was simulated to determine the effect of disconnecting the roof leaders of residential dwellings and diverting roof drainage to pervious areas such as lawns. The simulation was conducted by altering the amounts of impervious and pervious surfaces within each sewershed on the basis of total residential area and typical proportions of roof area to total impervious area. This method was adopted to account for the reduction in both storm runoff and pollutants associated with this control option. This

simulation assumed the disconnection of roof leaders in each sewershed within the urban Humber basin.

Retention Ponds in Residential Areas

This option represented the use of stormwater retention ponds to control pollutant release from residential land uses. The method of simulation was identical to that used for industrial retention ponds. Removal efficiencies differed from those used in the industrial simulation because of the different characteristics of solids washed from residential areas. In order to reflect the greater difficulty in acquiring suitable sites for residential ponds, removal efficiencies were based on a reduced pond size, representing 0.5% of the contributing area.

Elimination of Dry Weather Contamination

The methodology adopted entailed reducing dry weather inputs equivalent to the daily dry weather load from selected storm sewers. Only those storm sewers which had been identified as priority outfalls were used in the analysis (TAWMS, TR# 1, 1983). The evaluation produced an indication of the relative importance of dry weather source controls.

Disinfection

This option represented the use of disinfection techniques to reduce bacterial loadings from low flow in high priority areas (Black Creek, Emery Creek). Disinfection was assumed by ultraviolet irradiation. This technique is also compatible with stormwater retention ponds for increased control of bacteria.

As noted elsewhere, the pollutant removal efficiencies used in the simulations vary by parameter and control option. Simulation of CSO control, roof leader disconnection and dry weather control did not

require the use of percentage reduction factors. The factors used in the simulation of the remaining control options are shown in Table 7.2. The variable removal rates associated with the various metals is a result of differences in the typical dissolved and solids associated fractions in urban runoff.

Evaluation of the control scenarios was conducted in a cumulative manner with the effects of each being combined with those previously considered. This limited the number of runs and allowed evaluation of the total effect of a maximum control effort on in-stream water quality.

TABLE 7.2 : POLLUTANT REDUCTION EFFICIENCIES

Control	Assumption	Pollutant Reduction Assumed SS	Pb	Zn	Cu	FC low	FC high
Industrial Ponds	1%* of contributing area dedicated to ponds	95%	95%	59%	20%	50%	80%
Street Sweeping	Residential Area 3x/week	3%	9%	3%	3%	-	-
Catchbasin Cleaning	2x/year	15%	15%	8%	8%	-	-
Residential Ponds	0.5%* of contributing area dedicated to ponds	85%	87%	53%	20%	50%	80%
Disinfection	dry weather flow only	-	-	-	-	-	99%

Source: "Urban Runoff Controls Manual of Practice" - Gartner Lee & Associates, 1985.

* Pond areal requirements are based on an assumed active storage depth of 2 m and a design volume sufficient to store 20 mm of runoff.

8. FORMULATION AND EVALUATION OF MANAGEMENT PLANS

A comprehensive management strategy for the Humber River will require the implementation of a variety of control options. Many options can only be evaluated qualitatively and decisions to incorporate or delete them from the management plan must be based upon judgement and experience. Options which more directly effect the build-up, transport or release of pollutants, however, can be evaluated quantitatively. It is possible to assess the pollutant reduction effectiveness of these options and to provide additional information which will form a basis for selection or rejection of the control.

The purpose of this chapter is to assess the water quality impact of various levels of pollution control on the Humber River, to examine the effectiveness of physical control options, to assess the benefits and costs of each option, and to discuss potential problems in implementation. Sufficient information is provided to allow the formulation of a management plan.

8.1 WATER QUALITY IMPACTS: METALS

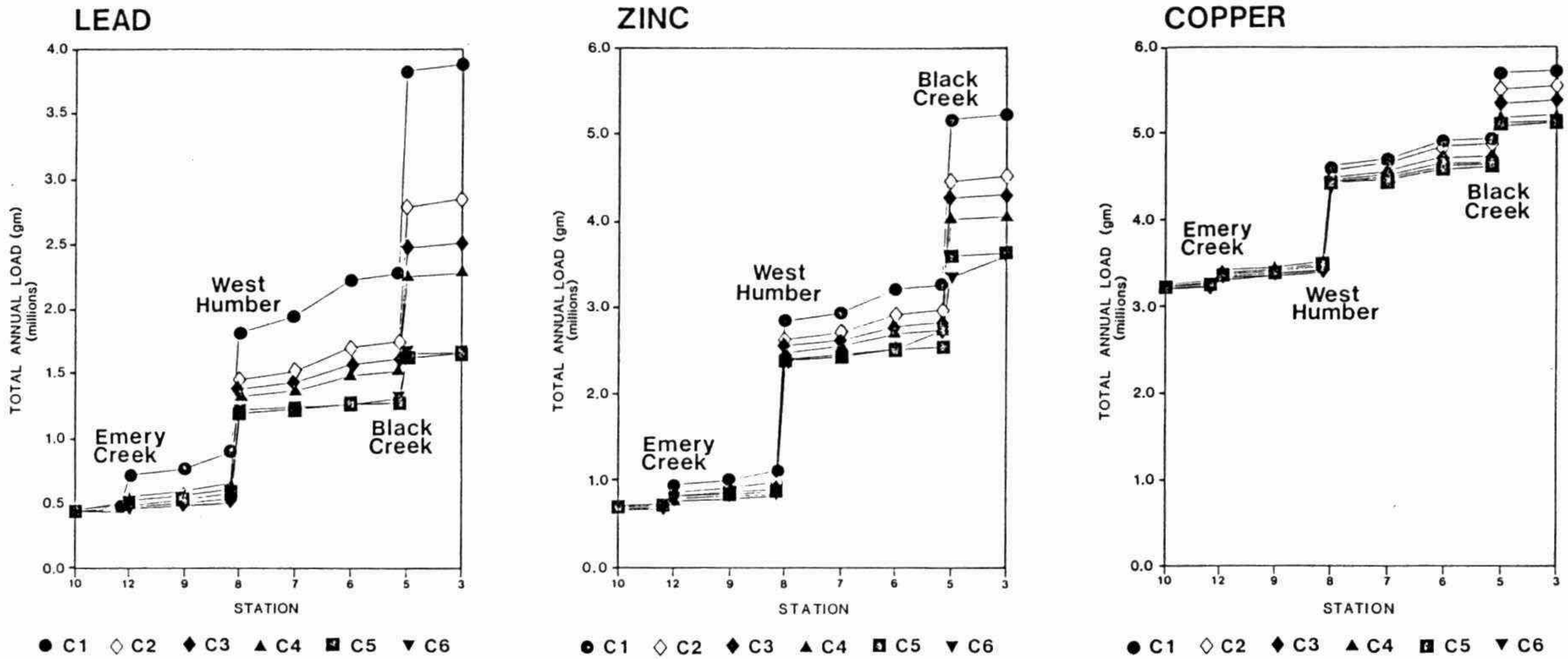
Computer simulations were run to allow evaluation of the various levels of control possible on the urban Humber. The simulations produced a great deal of information on water quality. Results are available for lead, zinc and copper at eight in-stream stations, in terms of load, concentration and duration of PWQO violations, for each successive level of control. In order to make this information clear and useful, a systematic approach to the presentation of results has been adopted. Water quality impacts, as defined by loadings, peak and mean concentrations, and PWQO violations, are presented separately. This information is then synthesized to provide a summary of the water quality improvements anticipated for the various levels of control. Water quality indices are provided to aid in summarizing the results and to indicate the utility of the control options in achieving the levels of control.

8.1.1 LOADING REDUCTIONS

Two views of metal loads are presented. In the first instance the load reduction resulting from each additional level of control is provided for in-stream stations, moving down the river. These results identify the impact of control options on loading to the lake and indicate the relative importance of each control option across the entire urban basin. The results also indicate the magnitude of tributary load contributions. Next, the cumulative effects of control options are presented individually by station. This information provides a clear picture of the relative utility of the options in the various portions of the basin. In combination, the load results indicate the magnitude of pollution reduction possible in the urban portions of the basin. It is noteworthy that the impacts of options vary according to the land uses present and the potential for implementation of a specific control. The load information provided for Station 3 (Bloor Street) provides insight into the overall effect of control options on total loading to Lake Ontario.

Figure 8.1 indicates the anticipated in-stream load reductions under the cumulative impact of the control options. Major reductions in lead and zinc loads are possible under the full program of control options, assuming that full scale implementation is practical. Considering only the loads generated by the urban catchments, lead can be reduced to 14% and zinc to 27% of the existing condition load. A program of controls using industrial retention ponds alone could reduce lead to 66% and zinc to 83% of the existing condition, if applied throughout the urban catchments. The percentage reductions in urban loads at the mouth of the Humber (i.e. excluding loads generated above Steeles Avenue and the Claireville Reservoir) are shown in Table 8.1 for all control options.

The effectiveness of the control options vary according to the characteristics of the contaminant. Retention ponds combined with catchbasin cleaning can remove 68% of the lead produced by the urban catchments. The remaining control options will have only a limited impact on urban lead loads. In order to produce a similar removal



CONTROL OPTIONS	
C1	Existing Conditions
C2	Industrial Ponds
C3	Street Sweeping and Catchbasin Cleaning
C4	Disconnection of Roof Leaders
C5	Residential Ponds
C6	Elimination of Dry Weather Sources

STATION NO.	LOCATION
10	Steeles Ave.
12	Emery Creek
9	Sheppard Ave.
8	West Humber
7	Lawrence Ave.
6	Eglinton Ave.
5	Black Creek
3	Bloor St.

FIGURE 8.1 : HUMBER RIVER TOTAL ANNUAL LOAD BY STATION

TABLE 8.1 : PERCENTAGE REDUCTIONS IN TOTAL ANNUAL URBAN LOAD BY CONTROL OPTION AT STATION 3

Control Option	Reduction in Urban Loading (%)		
	Pb	Zn	Cu
CSO Elimination	4.8	7.7	5.2
Industrial Ponds	33.8	16.8	6.5
Streetsweeping and CB Cleaning	12.4	7.3	10.7
Roof Leader Disconnection	7.7	7.8	9.7
Residential Ponds	24.2	15.8	6.8
Dry Weather Flow Control	3.0	17.9	4.6
Total-All Options	85.9	73.2	43.6

for zinc, elimination of the CSO and mitigation of dry weather sources would be required. Few of the control options will have a significant effect on copper and it would require a full program of controls to affect a 44% removal of urban-generated copper.

The significance of the overall reduction of urban loadings should be considered in relation to the background loads generated by the upper Humber. A full program of urban controls would reduce the total annual loads of lead, zinc, and copper by 59%, 40% and 11% respectively. It is noteworthy that the small reduction in total annual copper load is partly an artifact of the very high loads generated for the upper Humber through statistical analysis of limited data. The high background load for this parameter was not confirmed during calibration and testing. If the background loading of copper is less than suggested by the statistical analyses, then the relative impact of urban copper reductions would be increased.

Figures 8.2 a-e show the effects of the control options on loads at stations on the main branch of the Humber River. Station 10, located at Steeles Avenue, is unaffected by the control options as it is assumed that the options will only be applied within Metropolitan Toronto initially. Station 9, at Sheppard Avenue, shows a small reduction in the loadings of lead and zinc as a result of industrial pond controls on Emery Creek. The dramatic effect of controls on Emery Creek is masked by the dominance of upper Humber loads at Station 9. Station 7, at Lawrence Avenue, and Station 6 at Eglinton show the increasing impacts of urban controls on lead and zinc, as larger segments of the watershed are controlled. Although each of the control options contributes to a gradual reduction in urban loads, the option involving industrial retention ponds has the greatest impact because of the concentration of industrial land uses above Highway 401. Station 3, located at Bloor Street shows a dramatic reduction in loads as a result of the impacts of controls instituted on Black Creek.

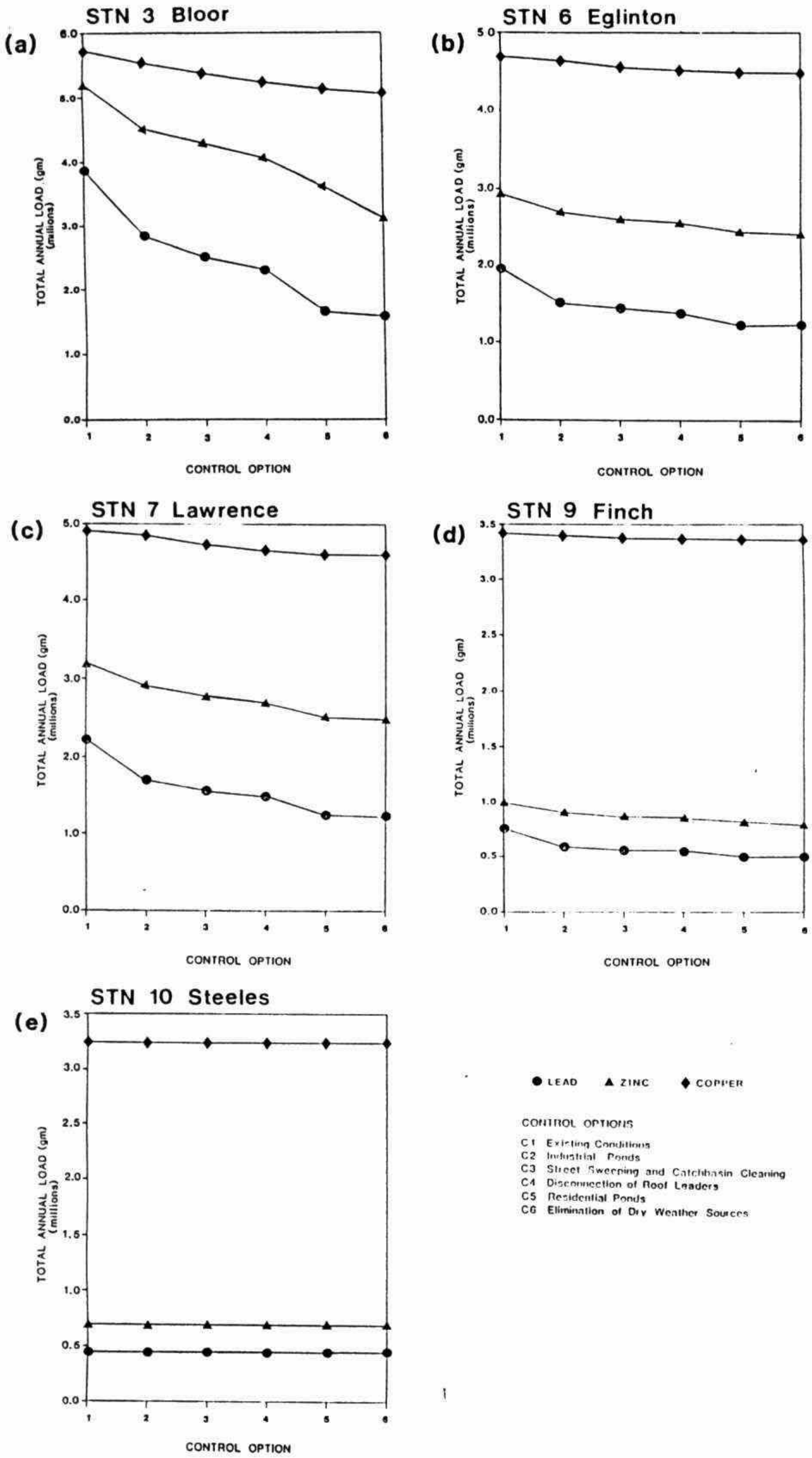


FIGURE 8.2 : LOAD REDUCTION BY CONTROL OPTION FOR MAINSTREAM STATIONS

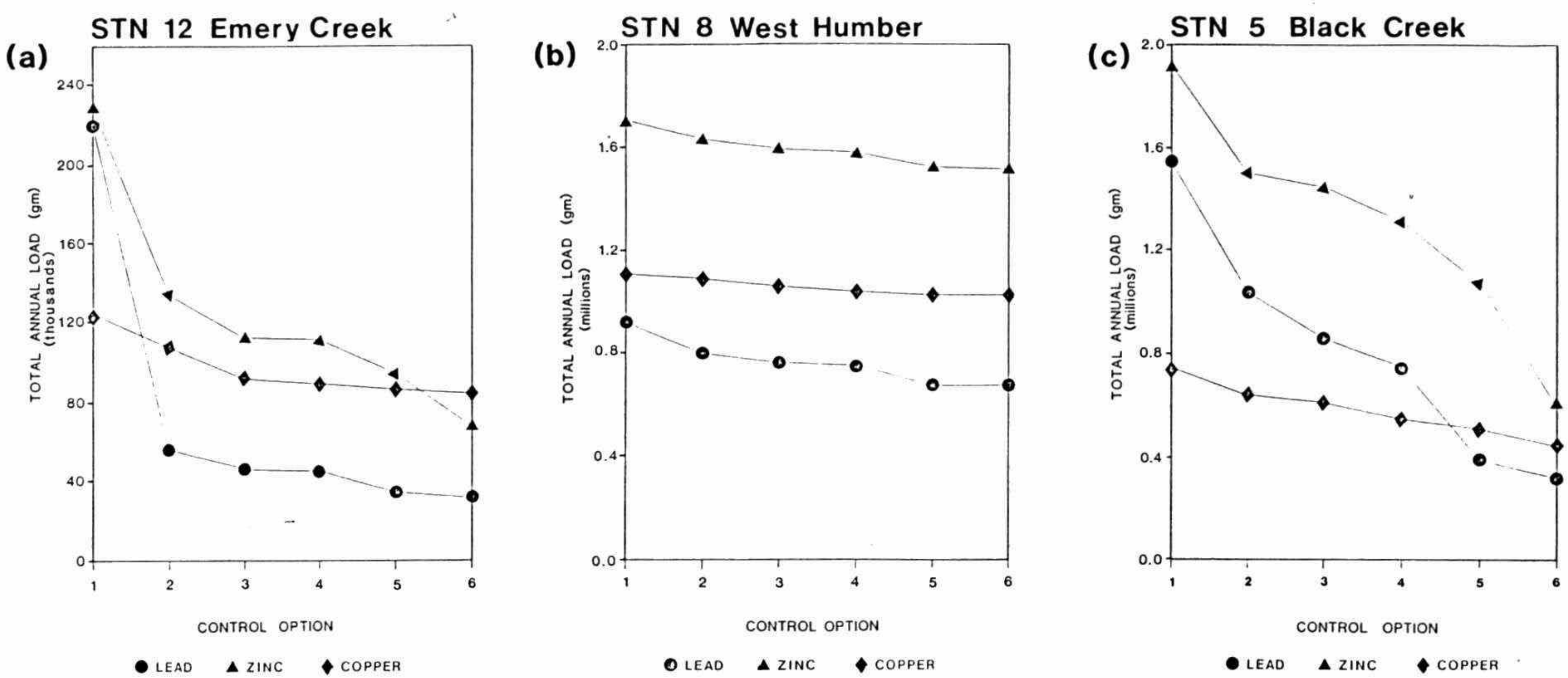
Figures 8.3 a-c demonstrate the effect of control options at the tributary stations on Emery Creek, the West Humber, and Black Creek. Station 12, on Emery Creek shows a major load reduction for lead and zinc as a result of the industrial pond option. Only limited reductions in lead loading can be produced for this area through the institution of the other control options. Significant reductions in zinc loads can be accomplished through catchbasin cleaning, residential ponds and mitigation of dry weather sources. Roof leader disconnection has virtually no impact on this basin. Station 8 at the confluence of the West Humber shows a small impact on lead and zinc loads as a result of retention ponds in industrial and residential areas. The reduction in urban generated loads is significant but the overall impact on total reach load is masked by contributions from rural areas above the Claireville Reservoir.

Station 5, at the mouth of Black Creek, shows the most dramatic effect of the control options. All of the control options have a significant effect on lead and zinc loads. Industrial and residential ponds, combined with the elimination of CSO, would have the greatest impact on reducing loads generally. Mitigation of dry weather sources would make a major impact on zinc.

8.1.2 IN-STREAM CONCENTRATION REDUCTIONS

Loading results provide useful information regarding the magnitude of pollutant reduction possible. In order to examine the effects of different levels of control on water quality in the Humber, it is necessary to consider concentrations of each metal in relation to the applicable PWQO.

Figures 8.4, 8.5, and 8.6 show the effects of the various control options on in-stream concentrations for lead, zinc and copper respectively. Each figure indicates the maximum concentration simulated over a one year period, together with the arithmetic mean concentration and the applicable PWQO. The results are discussed separately for each parameter.



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

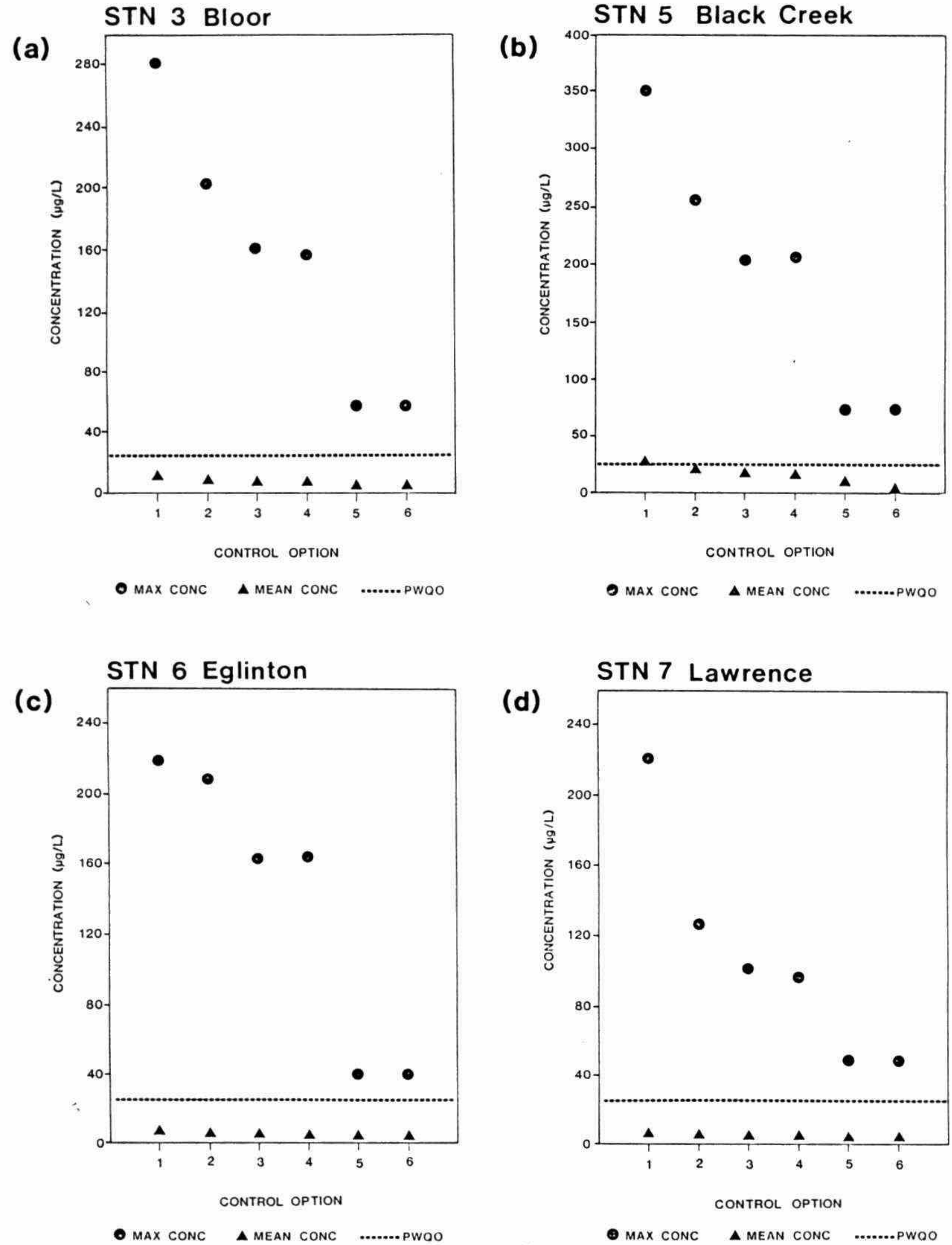
FIGURE 8.3 : HUMBER RIVER LOAD REDUCTION BY CONTROL OPTION FOR TRIBUTARY STATIONS

Lead

Under existing conditions (control option #1), the average concentration of lead is less than the PWQO of 25 ug/l at all stations except Black Creek at Scarlett Road (Station #5). Peak concentrations exceed the PWQO at all stations under existing conditions. The degree of exceedence is relatively minor at Steeles Avenue (35 ug/l) but climbs to significant levels (220 ug/l) through the middle reaches, as Emery Creek and the industrial areas above Highway 401 contribute their load. The peak concentration on the main Humber is highest at Bloor Street (280 ug/l) as a result of the influx from Black Creek. This concentration is below the acutely toxic limit (400 ug/l) suggested by the U.S. EPA (1980a).

Average concentrations of lead are reduced at all in-stream stations as successive control options are implemented. The benefit of these reductions is minor, as the average concentrations are below the PWQO at all stations except Black Creek. The major impact of the control options is manifest by the reductions in peak concentrations. Dealing first with the tributary stations (12, 8, 5), it is evident that industrial retention ponds will have a major impact, reducing peak concentrations by 60 to 350 ug/l. Catchbasin cleaning and residential ponds will provide a further significant reduction in peak concentrations on the West Humber and Black Creek because of the contribution of lead from residential sources in these areas.

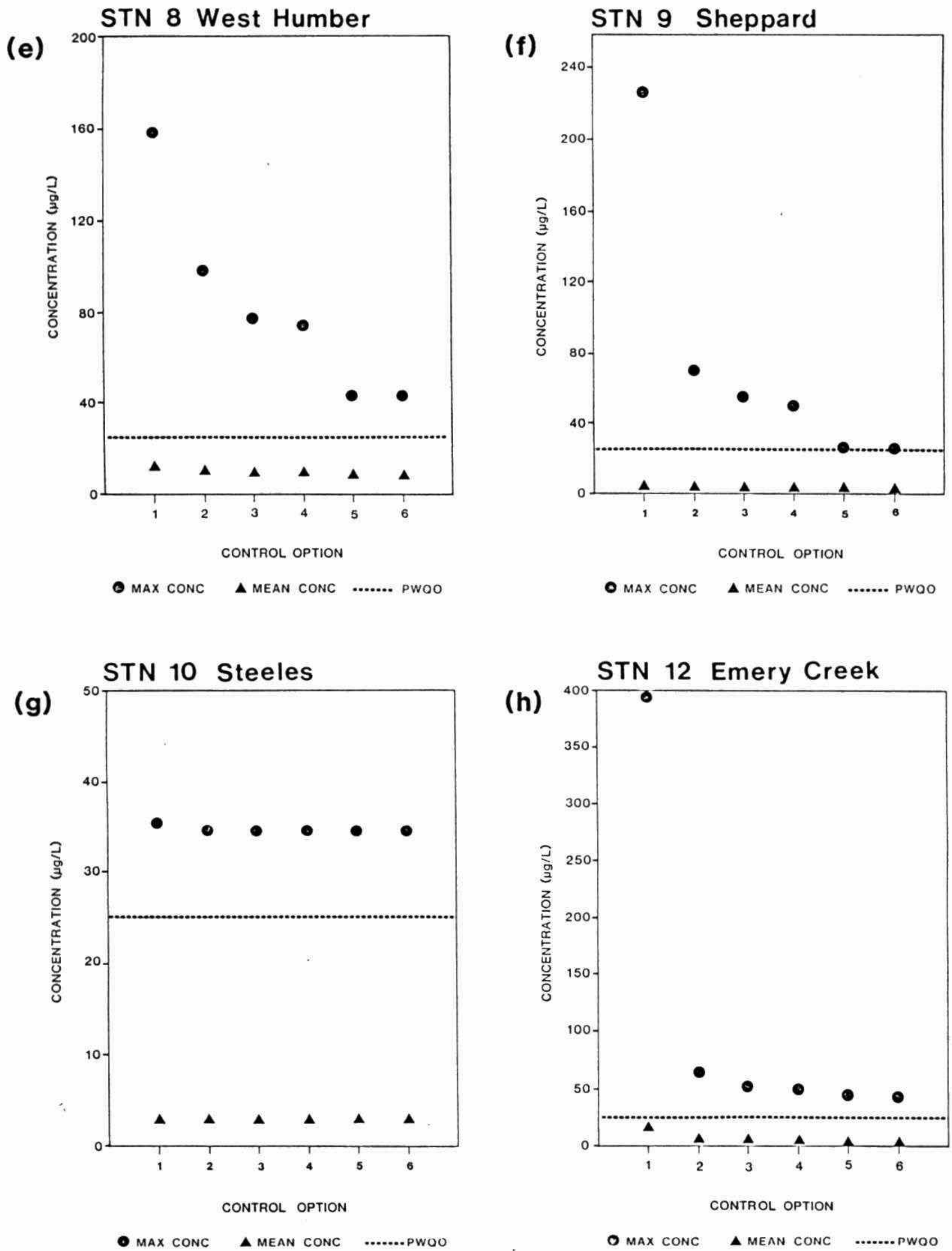
The results for the main Humber stations (10,9,7,6,3) demonstrate the spatial impact of the control options. The control options have no effect on the upper Humber as indicated by the results at Steeles Avenue. Background concentrations will result in occasional PWQO violations at this station regardless of the urban controls implemented. The results at Stations 9 and 7 show the importance of industrial controls in the upper part of the basin. Catchbasin cleaning, and residential ponds also have a significant impact. At Station 6, the effectiveness of the controls shifts, with the residential controls (ponds, catchbasin cleaning) becoming more important. This shift is caused by routing effects and the greater impact of runoff from residential land use in the middle and



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.4 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION: LEAD



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.4 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION: LEAD

southerly portions of the basin. The impact of both industrial control and residential control is again manifest at Station 3 as a result of the influx from Black Creek.

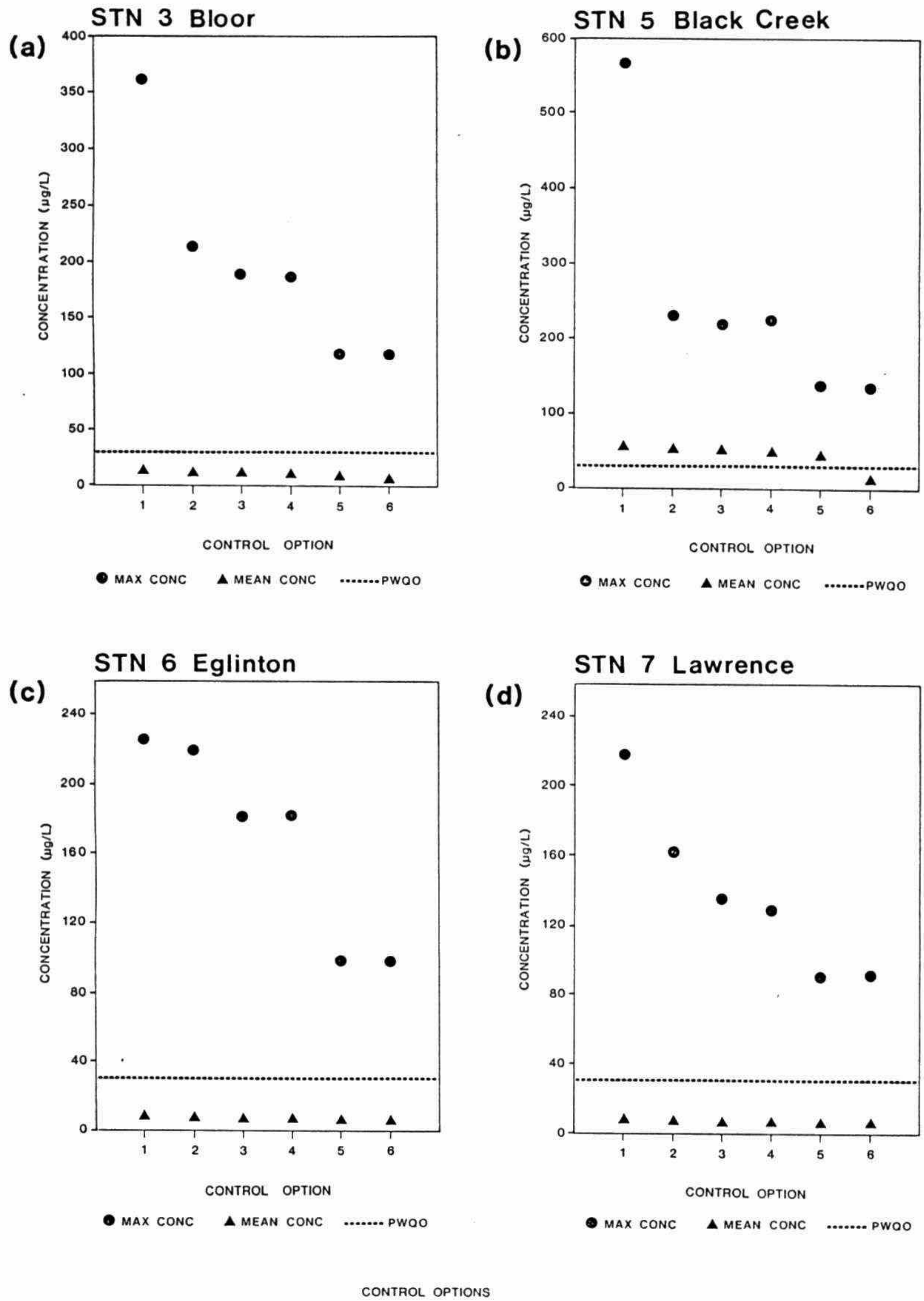
Overall, it is apparent that peak concentrations of lead can be reduced through the use of industrial ponds in the north, residential controls in the middle portion of the basin and a combination of both types of controls on Black Creek. The control options involving disconnection of roof leaders and mitigation of dry weather sources will have limited impact on peak concentration. The institution of industrial controls alone in the catchments above Highway 401 will not be sufficient to effect major reductions in peak concentrations in the lower reaches of the Humber River, because of the impact of Black Creek and the residential catchments in the central and southern portions of the basin.

Although violations of the PWQO for lead cannot be completely eliminated through the options considered, a significant reduction in peak concentrations is possible. A full program of controls, instituted across the basin could reduce peak concentrations to about 40 to 60 ug/l. As will be discussed in Section 8.1.3, the duration and frequency of these violations can also be reduced.

Zinc

Under existing conditions the average concentration of zinc is below the PWQO of 30 ug/l at all stations except Black Creek (Station #5). Average concentration of zinc approaches the PWQO on Emery Creek. Peak concentrations of zinc exceed the PWQO at all stations. Below Station 10, the degree of exceedence gradually increases reaching a level of about 350 ug/l at Bloor Street. Black Creek and Emery Creek are significant contributors of peak zinc concentrations (575 ug/l and 300 ug/l respectively) under existing conditions. Simulated peak concentrations of zinc in Black Creek, exceed the acute toxicity limit (570 ug/l)suggested by the U.S. EPA (1980b).

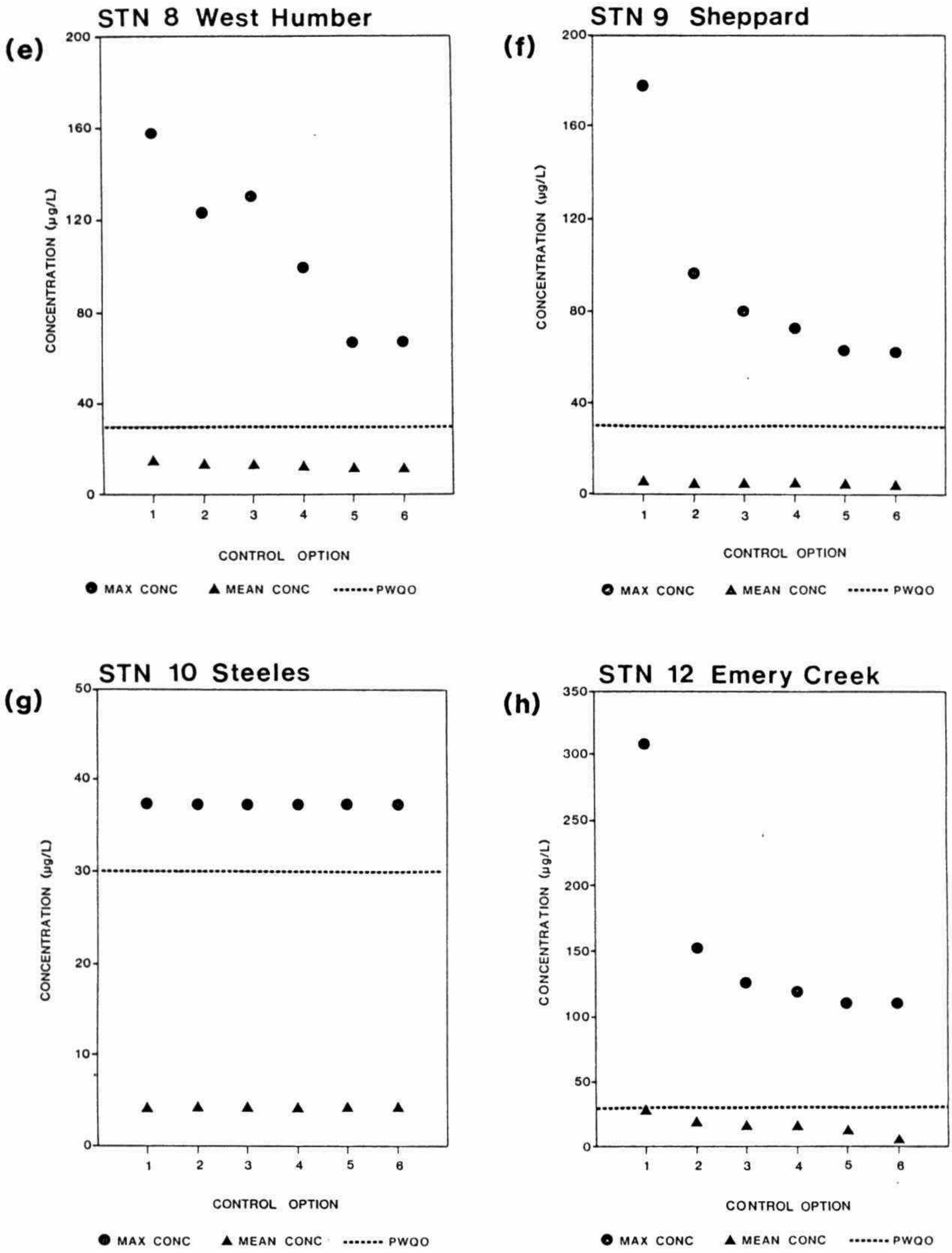
In general, the relative effectiveness of the control options in reducing peak zinc concentrations is similar to that discussed for



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.5 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION : ZINC



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.5 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION : ZINC

lead. There are benefits to industrial controls in the north which should be augmented by residential controls in the central portion of the basin. Control of Black Creek, especially in terms of industrial control, is important in order to reduce concentrations in the lower reaches.

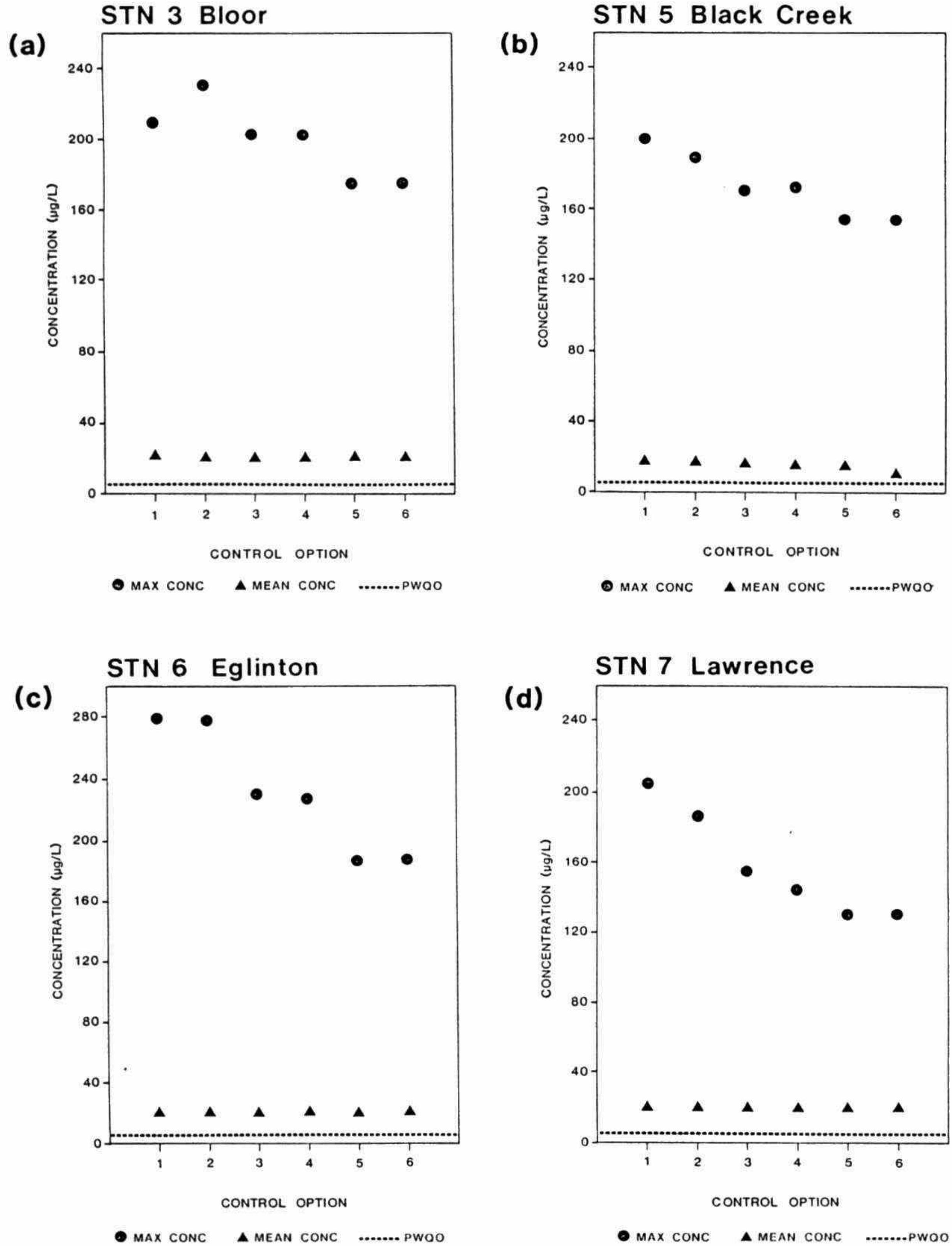
The principal differences between lead and zinc are twofold. Zinc is less easily controlled than lead and as a result the absolute reduction in peak concentration is less for zinc. In general, the peak concentration of zinc may be expected to be about twice that observed for lead. Secondly, average concentrations of zinc exceed the PWQO on Black Creek by a substantial amount. This results from high concentrations during dry weather conditions. The only control option which would have a significant impact on average concentrations on Black Creek would require the mitigation of dry weather sources.

As discussed for lead, it is not possible to eliminate PWQO exceedences for zinc, even if all control options considered are implemented. A complete program of control options, instituted throughout the basin, could reduce peak in-stream concentrations to 70-110 ug/l (PWQO is 30 ug/l).

<u>Copper</u>

The simulation results for copper cannot be considered reliable in terms of absolute magnitude because of the high (20 ug/l) average concentrations derived from the statistical analysis of limited data for the upper Humber. Figures 8.6 a-h have been included primarily to demonstrate the relative effectiveness of the control options.

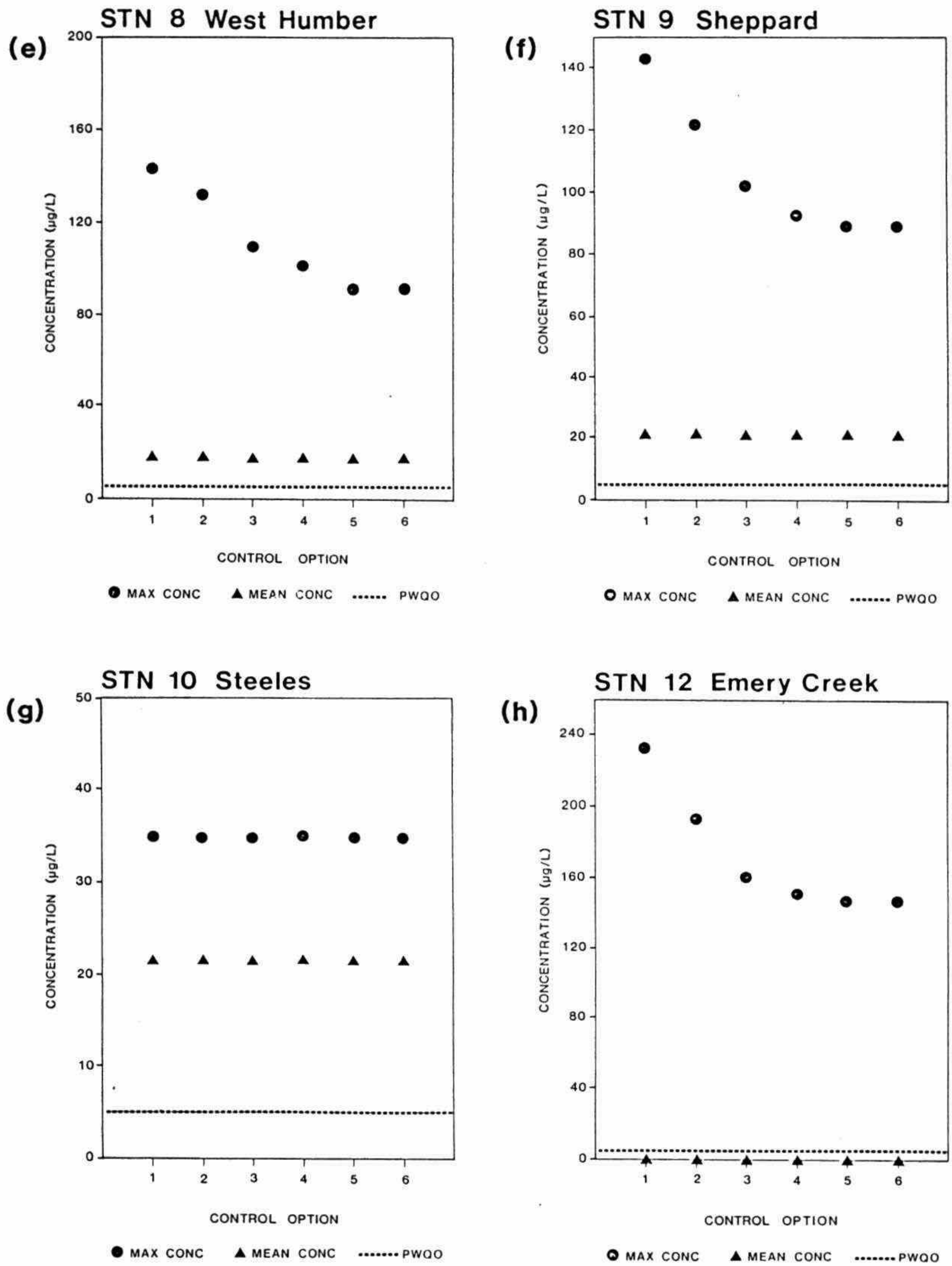
In general, the copper contributed by urban sources appears to be well distributed. As a result, controls affecting all land uses will be necessary to produce an impact on peak copper concentrations. The effectiveness of the control options tested is quite limited for copper. Simulations suggest a reduction in peak concentrations of only 10 to 35% if a full program of controls is implemented. It therefore appears that there will be little benefit derived from



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.6 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION : COPPER



CONTROL OPTIONS

C1 Existing Conditions
C2 Industrial Ponds
C3 Street Sweeping and Catchbasin Cleaning
C4 Disconnection of Roof Leaders
C5 Residential Ponds
C6 Elimination of Dry Weather Sources

FIGURE 8.6 : MAXIMUM AND MEAN CONCENTRATIONS BY CONTROL OPTION : COPPER

controls aimed specifically at copper. Control options aimed at removal of lead and zinc will have an impact on copper concentrations.

Further discussion of copper is warranted given the lack of confidence in the simulation results for this parameter. The PWQO for copper is 5 ug/l. The acute toxicity criteria suggested by the U.S. EPA (1980c) is 42.5 ug/l. During the course of TAWMS, minimum concentrations were about 8 ug/l at stations below Steeles Avenue. Peak concentrations, exceeding the toxic criteria, were observed at several stations during wet weather and spring runoff. It is evident therefore, that copper concentrations are of concern on the Humber River. Further study is required to determine more precisely the effect of this parameter on aquatic life. In the interim, any control option which may reduce copper concentrations should be considered a benefit.

8.1.3 Control Options: PWQO Violations

The peak concentrations of all metals are likely to continue to exceed the Provincial Water Quality Objectives at all stations on the Humber River regardless of the control options implemented. The extent of exceedence will be reduced by the control options, but it is difficult to assess the significance of a reduction in peak concentration in terms of overall water quality. In order to clarify the impact of control options on in-stream water quality, it is necessary to examine the frequency and duration of PWQO violations. Figures 8.7 a-c show the amount of time spent in violation annually, together with the number of violation events for each control option. Station 10 (Steeles Avenue) is not shown in the figures because the control options considered do not impact on land upstream of this point.

Lead

Extensive violation of the PWQO for lead occurs on each of the major tributaries (Stations 12, 8, 5) under existing conditions. Industrial ponds on Emery Creek (Station 12) will have a major

(a) LEAD OVER PWQO

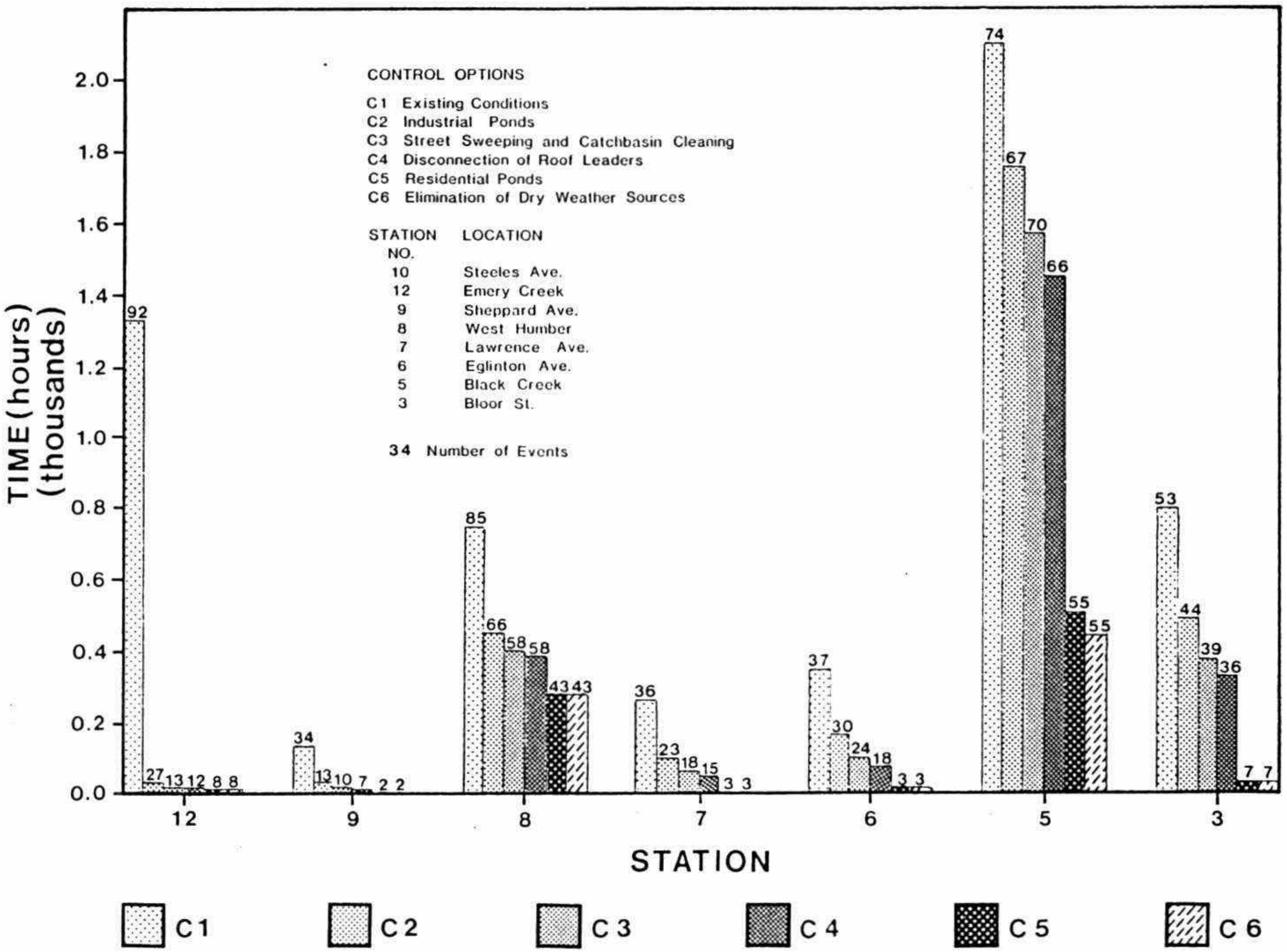
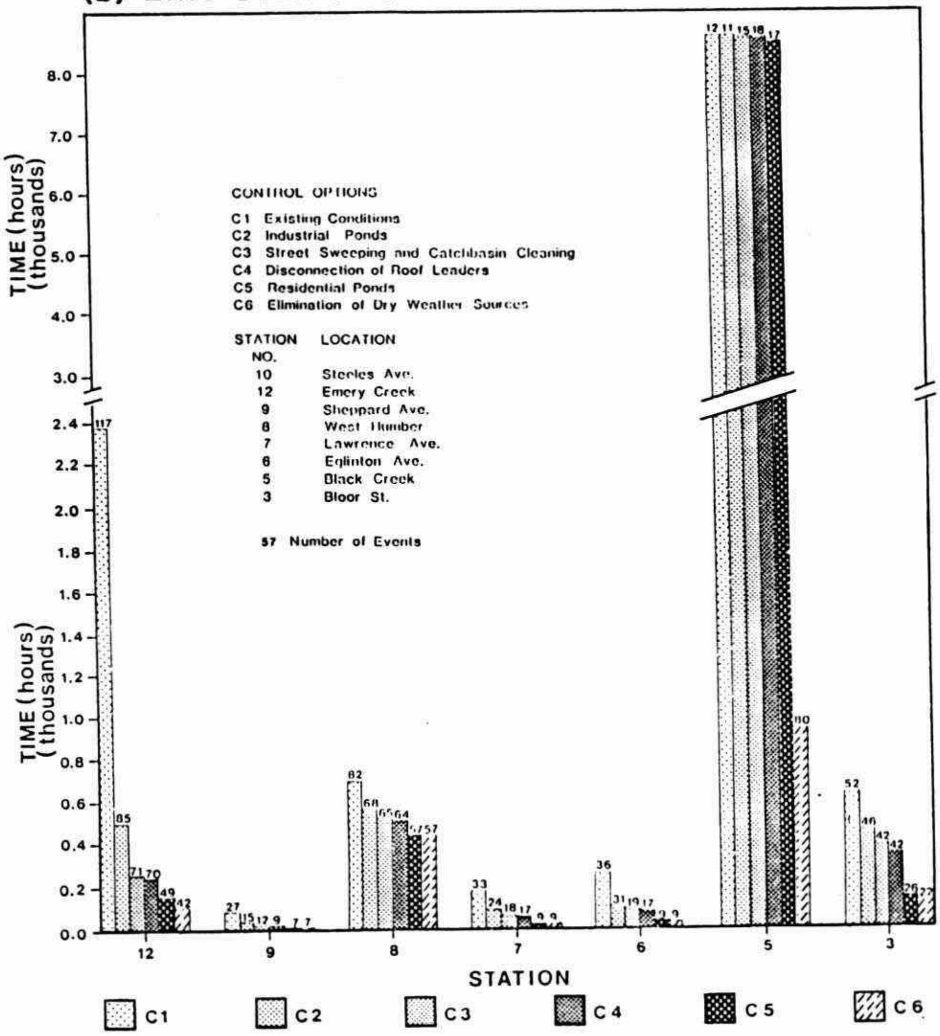


FIGURE 8.7 : TOTAL TIME SPENT IN VIOLATION

(b) ZINC OVER PWQO



(c) COPPER OVER 40 μg/L

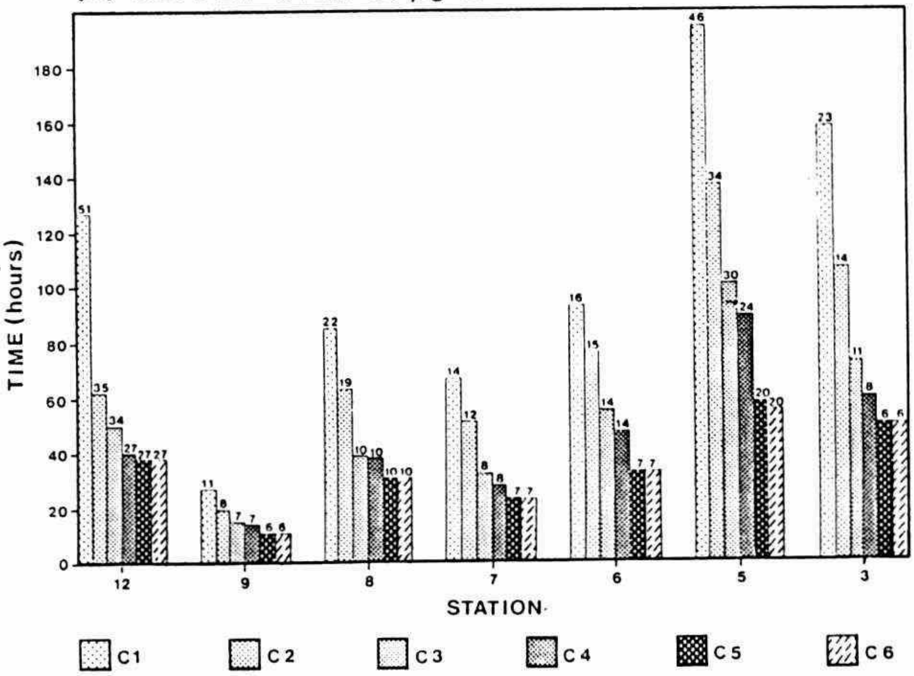


FIGURE 8.7 : TOTAL TIME SPENT IN VIOLATION

impact, reducing the 92 violations with an average duration 14.4 hours under existing conditions, to 27 violations with an average duration of 1.3 hours. Additional control measures on this sub-basin will reduce the number of violations but will have little impact on the total length of time spent in violation of the PWQO.

The West Humber (Station 8) will also benefit from the implementation of industrial ponds, with a reduction from 85 violations averaging 8.7 hours in duration under existing conditions, to 66 violations with an average duration of 6.6 hours. Catchbasin cleaning, together with residential ponds will have a further significant impact in reducing the number of violations. A relatively high number of violations will continue to occur on the West Humber, even if a full program of controls is implemented (43 violations; 6.4 hour average duration), because of poor quality of discharge from Claireville Reservoir.

PWQO violations are most significant on Black Creek, with 74 violations occurring for an average 28.5 hours. Black Creek is in violation of the PWQO for lead about 25% of the time on an annual basis. The impact of individual control options is limited because of the large tributary area and the diversity of land use. A full program of controls would reduce the number of violations to 55 with an average duration of 8.1 hours. Although Black Creek would continue to produce a large number of violations with full control, the reduction in average duration of exceedence would have a major impact on downstream areas of the main Humber.

The number and duration of PWQO violations on the Humber River tributaries is substantial under existing conditions. The impact of the tributary influx of contaminants is mitigated to some extent however, by dilution at most of the main Humber stations. Violations occur 30 to 40 times annually at Stations 9,7, and 6 for durations ranging from 4 to 10 hours on average. Industrial pond controls in the upper sub-basins would reduce the number and length of violations to a great degree. Introduction of additional controls such as catchbasin cleaning and residential ponds would reduce the number of annual violations to 2 to 3 of 1 to 3 hour durations at each of the main Humber stations above Black Creek.

The impact of Black Creek has a significant influence on the Humber reaches below the confluence at Scarlett Road, and on the near shore environs of the Lake. Although a full scale pollution control effort would not eliminate water quality problems on Black Creek, it would have a major impact on violations in the lower Humber approaching the Lake. Simulations indicate that violations in these reaches could be reduced to 7 annually, with an average duration of about 4 hours. Because of the diversity of land use on the Black Creek watershed, anything less than a full program of controls would have minimal impact on the lower reaches of the Humber River.

Zinc

In general, PWQO violations for zinc follow a similar pattern to that depicted for lead at the various tributary and main stream stations. Two of the tributary stations, Emery Creek and Black Creek show markedly higher levels of violations for zinc under existing conditions. On Emery Creek, 117 violations with an average duration of 20 hours may be expected to occur annually. This means that the Creek is in violation approximately 25% of the time. On Black Creek the situation is far worse, with PWQO violations occuring 98% of the time under existing conditions. This is evident from the average duration of a violation on Black Creek (720 hours).

The control options tested are not as efficient in removing zinc as they are for lead. As a result, the reduction in the number and duration of violations is not as dramatic for zinc. Nevertheless violations at the upper stations (9,7,6) on the main Humber can be reduced to less than 10 per year with an average duration of 4 hours. Larger numbers of violations with longer average durations will continue to occur on tributary branches. Zinc violations will not be significantly reduced on Black Creek unless dry weather sources are eliminated. Even if dry weather sources are mitigated, it was estimated that approximately 80 violations with a mean duration of 12 hours will occur annually on this tributary. The impact of Black Creek limits the ability to reduce violations in the lower reaches of the Humber River.

Copper

Examination of PWQO exceedences is not meaningful for copper because of the high background concentrations generated through statistical analysis (20 ug/l versus the PWQO of 5 ug/l). An analysis of the control options ability to reduce exceedences of a higher level has therefore been prepared to demonstrate the impact of the controls on this parameter. The level selected (40 ug/l) approaches the limit for acute toxicity suggested by the U.S. EPA (1980c).

Simulated copper concentrations exceed 40 ug/l regularly at stations on the main Humber (typically 10-20 times per year). Exceedences occur more frequently and for longer durations on the tributaries. As in the case of zinc, the effect of control options is not as great as for lead. A full program of controls would be required to produce significant reductions in copper exceedences. It is unlikely that any set of urban controls could reduce copper to levels approaching the PWQO.

Other Parameters

Other chemical parameters, most notably cadmium and phosphorus, are of concern in the Humber River. Cadmium is a highly toxic metal which may have a significant impact on the fishery. Violations of the PWQO have been observed for this metal in the Humber River. The standard for Cadmium (PWQO is 0.2 ug/l) is very low and quite close to the detection limit used during TAWMS sampling. As a result, it was not possible to formulate estimates for cadmium loading during this study. Cadmium loads are often well correlated with lead in urban environments, because they result from similar sources. It is anticipated that control options which will reduce lead inputs to the river will also have an effect on cadmium, although it is likely that removal efficiencies will not be as high in relation to the PWQO.

Phosphorus also exceeds the PWQO of 30 ug/l within the Humber River. In general, the problems most often present in rivers with high phosphorus concentrations, such as low dissolved oxygen and excessive weed and algal growth, are not notable in the Humber. The

principal concern with phosphorus relates to the load delivered to the lake. Enhanced Tributary Monitoring data collected by MOE between 1980 and 1984 indicate a range of total phosphorus loads between 29,000 kg/yr and 93,000 kg/yr. It is estimated that the typical annual load is in the order of 56,000 kg. Much of the phosphorus load in the Humber River is generated in the upper part of the basin, above Steeles Avenue and the Claireville Reservoir. Agricultural control programs and sediment controls will reduce the phosphorus loads from the upper Humber, but the extent of the reduction cannot be estimated. It is anticipated that the urban portion of the Humber basin contributes between 8,000 and 15,000 kg of phosphorus on an annual basis. Urban controls which seek to reduce pollutants through sediment control will be effective in reducing phosphorus loads. Stormwater ponds, for example, typically remove 50% of the influent phosphorus. Based on modelling results for suspended sediment control from urban sources, it is estimated that a full program of urban controls would reduce the typical annual phosphorus load by approximately 2,800 kg. This represents about 5% of the estimated total annual total phosphorus load to the lake.

8.2 WATER QUALITY IMPACTS: BACTERIA

Contamination of the Humber River by fecal indicator bacteria must be viewed in a fundamentally different manner from the contamination of the river by conservative substances such as heavy metals. Concentrations of fecal indicator bacteria decrease as they move downstream from their source, because of natural die-off and sedimentation. The selection of a single location for assessing the impacts of control measures will therefore introduce a bias, emphasizing the importance of controls close to the selected site and down grading the importance of controls farther upstream. By way of example, if the effectiveness of controls is only assessed in terms of bacterial counts at the mouth of the Humber, then controls on Black Creek will be important, while those near Steeles Avenue will be less significant. This of course would mask the importance of upstream controls by giving no weight to reductions in bacteria counts in the upper reaches. As a result, it is important to examine bacterial contamination on the basis of in-stream reductions at a number of locations.

Bacterial contamination of the Humber River occurs both in dry weather and during runoff events. The causes of the contaminant loadings are quite different for the two cases. During dry weather, the main sources of fecal indicator bacteria within the urban Humber are contributions of small discharges from the numerous storm sewers within the watershed, and unknown amounts of direct contamination by non-domesticated birds and animals. A relatively small number of storm sewer outfalls contribute the majority of fecal indicator bacteria from the storm sewer system during dry weather. During the course of the TAWMS study some 52 outfalls were identified as priority outfalls in terms of bacterial contamination. Based on the high counts recorded at these outfalls it is believed that these sewers receive sanitary wastes from illegal connections, or other unusual contributions from unknown sources such as food processing industries. The quantity and impact of inputs from non-domesticated birds and animals was not investigated in this study. Reference can be made, however, to the Rideau River Stormwater Management Study which suggests this may be a significant source. If it is deemed necessary to implement bird controls one must ensure that the displaced bird populations do not pollute other locations.

During wet weather the situation changes. Instead of 52 outfalls contributing high bacteria counts, virtually all outfalls become potent sources of bacteria, as each catchment is flushed of its accumulated load.

It is noteworthy that bottom river sediments may also furnish a considerable bacterial load to the water column. Although at present little is known about the impact of this sediment source in the Humber River, other studies indicate that bacteria do not form a homogeneous system with the water body. Instead, they act as particulate matter and are precipitated or absorbed to larger floating particles. Under low flow conditions (dry weather), waterborne organisms are more prone to settle into the sediment. During high flow, the bacteria may be resuspended and transported farther downstream. A continuous or intermittent input could, therefore, produce a continuous, year-round source of pathogens and indicator bacteria over the entire length of the river.

The fecal coliform association with suspended particles and lake bottom sediments is important in the evaluation of the sedimentation component of the overall FC die-off rate. To describe declining bacterial densities, the term "disappearance" may be more appropriate. This term describes the observed phenomenon (which include sedimentation, predation, dilution and death) without implying that any one factor (such as death) is wholly responsible. A rapid decline in FC densities in the water column is generally assumed to imply a high die-off rate. It is more probable that bacteria populations in the river sediments have been augmented, potentially harbouring sufficient numbers of pathogens to create a health hazard to body contact users via resuspension.

The means available for controlling fecal pollution during dry and wet conditions differ markedly because of the number of sources and the magnitude of the flows involved. During dry weather, direct contamination by non-domesticated birds and animals is largely uncontrollable. The majority of the dry weather bacterial contributions from storm sewers can be eliminated, however, because of the relatively small number of priority outfalls. Elimination could be accomplished through either tracing and disconnecting illegal connections, or through intercepting the dry weather flows for diversion to the sanitary system. In either case, fecal contamination of the watercourse would be prevented. It is recognized, however, that tracing and disconnecting illegal connections cannot be completely effective and may require new methods of detection. Intercepting all priority outfalls may be prohibitively expensive or infeasible in certain instances. Consideration must, therefore, be given to treating the fecal contaminants once they have been released to the stream. This option would involve ultraviolet disinfection of dry weather flows at selected locations, usually near the mouth of a tributary stream. The mechanism of light-induced decay depends on the presence of endogenous sensitizers or chromophores which absorb light energy and cause cell damage. Other surrounding flora and fauna are generally not affected, as they possess pigments which absorb the excitation energy thus preventing cell damage. The disinfection

alternative is highly effective but it does have drawbacks, in that it would only benefit the main Humber River and not the tributaries. For this reason, it should be considered as an interim measure only. It is unlikely that disinfection of individual storm sewers discharging directly to the Humber River is practical due to the sum of costs for each individual disinfection unit. Tributary disinfection may be beneficial, however, because significant reductions of total bacteria, regardless of source (i.e. sewers or wildlife) are possible and the costs appear to be reasonable.

During wet weather, the elimination of storm sewer sources is impractical because every storm sewer becomes a major bacterial source. Interception of combined sewer overflow is a practical means of reducing bacterial loading during storm events because of the limited number of overflow points. Interception of other storm sewer discharges is impossible, however, because of the magnitude of the total discharge from storm sewers. Similarly, disinfection of natural tributary discharges is not possible because of the magnitude of the peak flows. The prevention of the buildup of fecal contamination on the urban catchment is possible through the enforcement of regulations such as dog and litter control bylaws. Regulation is a useful approach from both a water quality and an aesthetic point of view, although it can not be expected to be sufficient on its own. The only other practical means of reducing bacterial loadings to the river is through retention in stormwater ponds. These facilities would capture runoff and retain it for periods of one to two days, to allow time for the natural die-off and sedimentation of bacteria. A maintenance program would be implemented to remove the build-up of sediment. The retention facilities could be augmented by disinfection units to increase the levels of fecal pollution removal achieved. It should be recognized that the utility of retention ponds will be determined largely by the proportion of land which can be controlled (i.e. the number of sites available). A large number of storm sewer outfalls discharge directly into the Humber River and it would be impractical to attempt control of these individual outfalls through the use of retention ponds.

Based upon the above discussion it is evident that there are relatively few alternatives for the control of fecal pollution during either wet or dry conditions. The following sections indicate the feasible alternatives and their impacts on in-stream fecal indicator bacteria counts and loads.

8.2.1 DRY WEATHER CONTROLS

Under dry weather conditions the primary control emphasis must be the elimination of priority storm sewer outfalls, either through tracing and disconnection or interception. At two locations, Emery Creek and Black Creek, disinfection could be used as an alternative to the elimination of priority storm outfalls on the tributaries. Disinfection at the downstream end of each creek would not result in improvements to the water quality within the creeks, nor would it have any impact on outfalls discharging directly to the Humber River. It, therefore, cannot be considered an adequate substitute for complete elimination of major bacterial sources. Disinfection can, however, produce the highest quality effluent (in terms of fecal indicator bacteria) and is, therefore, considered a useful interim measure for tributaries with high bacterial loads.

Data from the Dry Weather Outfall Study (TAWMS, TR #1, 1983) and supplementary MOE data collected in the summer of 1985 were used to assess dry weather conditions. The 1982 dry weather outfall study data includes FC and FS densities and discharges from various outfalls that were active during dry weather periods. The 1985 MOE dry weather data includes FC, E. coli, FS and P. aeruginosa densities in the Humber River at Steeles Avenue, Bloor Street and at Lakeshore Boulevard, and from the Humber River tributaries. A first-order mass balance computer model using this data as source inputs and incorporating die-off, was calibrated and verified for existing bacterial contamination conditions within the Humber River watershed. The die-off rates of bacteria found in the Humber River and Black Creek are currently unknown. A study is underway at the University of Toronto to determine the die-off rates of FC, E. coli, FS and P. aeruginosa in various reaches of the watercourses. For the

purpose of this study, which was to assess the cause and effect relationship of FC transport in the watercourses, a 90% FC reduction in 24 hours was assumed. The effects of control option implementation were then assessed using this model by reducing the bacterial source inputs to the river in accordance with control option effeciencies. Given the various assumptions and limitations of the computational procedure the model is useful in comparing the relative impacts of the concerned control options.

Figure 8.8a presents the simulated in-stream FC bacteria concentrations under existing dry weather conditions. A count of 800/100 ml was observed at Steeles Avenue, the beginning of the urban Humber. This value falls within the overall range of data (44 to 1300/100 ml) collected by MTRCA and the Metropolitan Toronto Works Department in this area. Bacteria concentrations typically exceed the PWQO of 100/100 ml in the upper Humber as a result of scattered urban activities and agricultural operations. These counts may be reduced through programs aimed at reducing livestock and wild animal access to the upper Humber and eliminating sanitary inputs. The possible success of such programs cannot be assessed quantitatively, however, and for the purposes of this study it has been assumed that high counts will continue. This is a conservative assumption and it should be recognized that rural control programs are likely to have a beneficial effect on bacterial contamination in the upper reaches of the urban Humber.

Moving downstream from Steeles Avenue there is a general decline in FC concentrations as a result of die-off until the confluence with Emery Creek is reached. This creek is a major source of fecal pollution and its input raises in-stream FC concentrations to about 1100/100 ml. After Emery Creek a decline in concentration is again manifest. Natural die-off reduces concentrations to about 300/100 ml just upstream of the confluence with Black Creek. At the confluence, the impact of Black Creek raises the concentration to approximately 450/100 ml. Just downstream of the Black Creek confluence, inputs from several priority sewers raises the in-stream

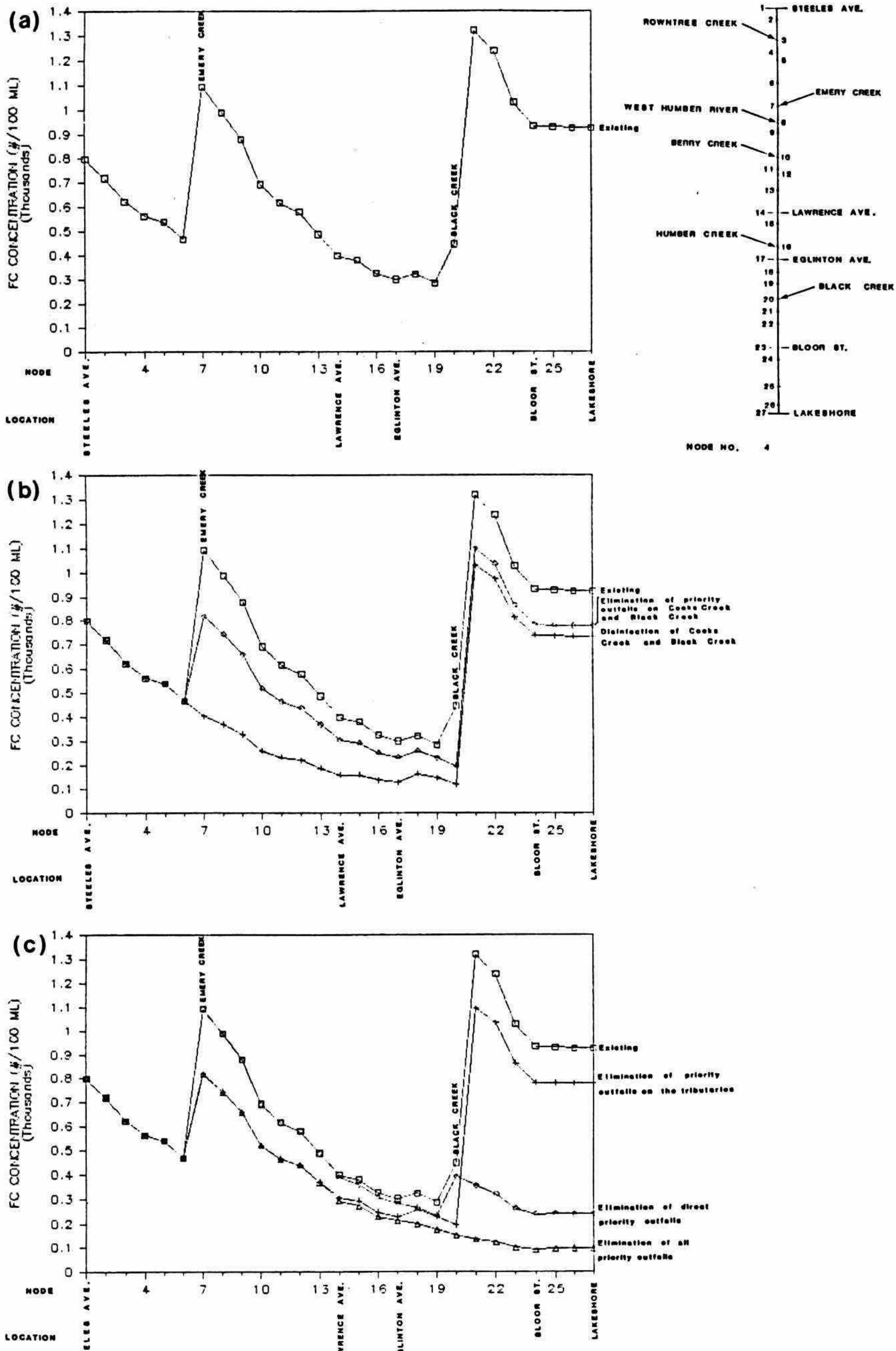


FIGURE 8.8: HUMBER RIVER SCENARIO TESTING - DRY WEATHER

FC concentration abruptly to about 1300/100 ml. Limited die-off below the confluence area reduces the concentrations to about 900/100 ml as the Humber River enters the lake.

Figure 8.8b indicates the impact of eliminating priority outfalls on Emery Creek and Black Creek or, alternatively, disinfecting their effluents. Each alternative has a significant impact on the Humber River, with the disinfection option being more effective because it acts on all sources of bacteria rather than just the priority outfalls. The presence of priority outfalls discharging directly into the Humber River and downstream of the confluence with Black Creek is sufficient, however, to raise concentrations to about 1000/100 ml. This demonstrates the importance of the priority sewers which outfall directly to the Humber River. Since the provision of disinfection at each outfall is not practical, it is clear that elimination of these outfalls, through either tracing and disconnecting or collection and treatment, is necessary if bacterial contamination of the lower Humber and the lake is to be reduced in dry weather.

Figure 8.8c indicates the impact of eliminating all priority outfalls. The concentrations of FC bacteria are reduced to approximately the PWQO (100/100 ml) in the lower reaches approaching the lake. Bacteria concentrations remain above the PWQO in the upper reaches because of the impacts of rural inputs. A significant overall improvement is achievable, however, during dry weather conditions. Table 8.2 outlines the anticipated impacts of implementing the different control options.

It should be noted that during the summer period, when recreational use of the Humber River is at its highest, dry weather conditions occur approximately 85% of the time. Dry weather controls would be expected to improve the bacterial water quality for this major time period. Dry weather controls would also have an impact on wet weather conditions, since deposited pollutant loads, normally subject to scour during wet events, would be reduced by dry weather controls.

TABLE 8.2 : DRY WEATHER SIMULATION RESULTS - Bacteria

Objective	Alternative	Observed Instream Count (#/100 ml)	Simulated Instream Count (#/100 ml)	Location	Impact Area
To reduce the bacterial load to the Humber River from Emery Creek for water quality enhancement in the upper reaches of the urban river	1) Eliminate priority outfalls on Emery Creek	1094	820	Humber River confluence with Emery Creek (Node 7 - see figure 8.8)	Humber River from Emery Creek confluence to Black Creek confluence
	2) UV Disinfection of Emery Creek	1094	403	Humber River confluence with Emery Creek	
To reduce the bacterial load to the Humber River from Black Creek for water quality enhancement in the lower reaches of the river and Humber Bay	1) Eliminate priority outfalls on Black Creek	446	196	Humber River confluence with Black Creek (Node 20 - see figure 8.8)	Limited to the Black Creek confluence area due to inputs from priority outfalls immediately downstream of Black Creek
	2) UV disinfection of Black Creek	446	120	Humber River confluence with Black Creek	
To reduce the bacterial load to the Humber River from the direct storm sewer outfalls for water quality enhancement throughout the river reaches (Note: Priority direct storm sewer loadings tend to be concentrated betweem Scarlett Road and Bloor St. - see figure 2)	1) Eliminate priority outfalls discharging directly into the Humber River i) reduce priority loadings by 50% ii) reduce priority loadings by 100%	 446 1029 932 926	i ii 441 390 662 259 599 235 598 238	Node 20 - Black Creek confluence 23 - Old Mill 24 - Bloor St. 27 - Lakeshore Blvd.	Mainly from the Black Creek confluence to Lakeshore Blvd. with minor impacts in the upper reaches
To reduce bacterial loadings from the Upper Humber Watershed for water quality enhancement in the upper reaches of the river	1) MTRCA policy - reduce background counts to i) 400/100 mL ii) 100/100 mL	 800 1094 693	i ii 400 100 900 755 571 480	 Humber River at Steeles Ave. Emery Creek Confluence Albion Rd.	Steeles Ave. to Albion Rd.
To reduce the total urban bacterial load to the Humber River (cumulative effect of all dry weather control options)	1) Elimination of priority outfalls discharging directly to the Humber River and the elimination of priority outfalls on the tributaries	800 1094 693 397 300 446 926	800 818 520 291 211 152 98	Humber River at Steeles Ave. Emery Creek Confluence Albion Rd. Lawrence Ave. Eglinton Ave. Black Creek Confluence Lakeshore Blvd.	Humber River from Emery Creek confluence to the Lakeshore
	2) Elimination of priority outfalls discharging directly to the Humber River and UV disinfection of Emery Creek and Black Creek	800 1094 693 397 300 446 926	800 401 258 147 107 75 52	Humber River at Steeles Ave. Emery Creek Confluence Albion Rd. Lawrence Ave. Eglinton Ave. Black Creek Confluence Lakeshore Blvd.	Humber River from Emery Creek confluence to the Lakeshore

8.2.2 WET WEATHER CONTROLS

Under wet weather conditions the major urban bacterial sources are the numerous storm sewer outfalls and the Combined Sewer Overflows (CSO). Contamination from the upper Humber is minor compared to these sources. CSO, although small in terms of volume compared to storm sewer discharge, is considered to be the most serious source because of very high FC counts and a greater potential for the presence of specific human pathogens. As noted previously, elimination of CSO appears to be a practical alternative because of the few overflow points. The only other alternative which can be quantitatively assessed, involves the use of stormwater retention ponds on selected tributaries. For the purposes of simulation, ponds have been assumed on Emery Creek, Berry Creek and Humber Creek. Ponds at these locations are deemed to be technically feasible. Although it is recognized that a greater degree of tributary control would be necessary to affect a significant reduction in FC load, simulation of ponds at these locations is able to demonstrate the type of impact expected from retention facilities.

Simulation of fecal indicator bacteria during wet weather conditions is substantially more difficult than during dry weather because of the effects of differences in timing of basin response, rainfall variations, routing of flows and the duration of impacts. Previous studies have attempted detailed simulation with limited success (Rideau River Stormwater Management Study, MOE, 1983). For the purposes of this study, a relatively crude method has been adopted, utilizing die-off and assuming steady state conditions at various points during a typical storm event. Additional data would be required before a more sophisticated modelling approach could be applied.

Figure 8.9 demonstrates the effect of the control options on hourly FC load at two stations; Bloor Street and Eglinton Avenue, each on the main Humber River. Loads are shown for hours 1, 3, and 10 of

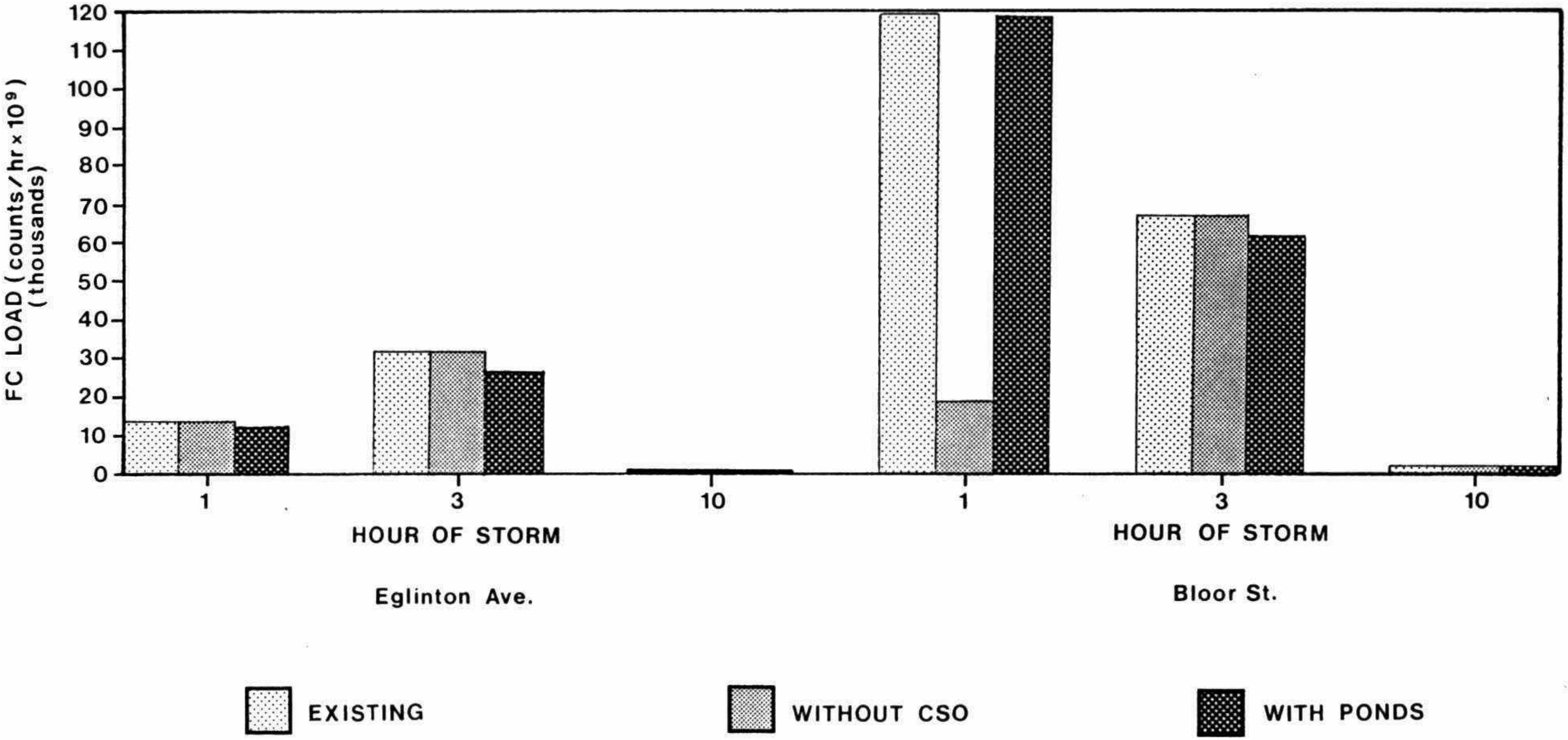


FIGURE 8.9 : HUMBER RIVER SCENARIO TESTING- WET WEATHER

the storm. The event simulated consisted of a four hour rainfall, with the maximum rainfall intensity ranging from 15.6 to 26.2 mm/hr across the basin.

Referring to Figure 8.9 it is evident that the elimination of CSO would have a major impact on initial FC loads at Bloor Street, reducing the hour 1 steady state load by 84%. By hour 3, however, the impact of CSO elimination has dropped to zero. This is typical of most rainfall events because overflows usually occur quickly and are of relatively short duration. CSO elimination has no impact at Eglinton Avenue, because the overflow points are located in the southern portion of the Black Creek subbasin.

The three retention ponds are all located on tributaries above Eglinton Avenue. A nominal reduction in FC load is noticable during hour 1 at both Eglinton Avenue and Bloor Street. By hour 3, the impact of ponds has reached a maximum, producing a load reduction of about 6%. The small amount of load reduction is the result of the limited area controlled and the fact that although the pond effluent volumes have been reduced, there has been insufficient time for substantial die-off. By the tenth hour, runoff from the urban areas has ceased and the loading noted is the result of inputs from the upper Humber. The ponds do not have much impact by this time, although continued discharge produces a very slight increase in FC loading.

The discussion of wet weather bacteria control has concentrated on the reduction in the loads of FC bacteria. It is noteworthy that the load reductions effected by the control options will not be sufficient to bring in-stream concentrations down to levels approaching the PWQO of 100/100 ml, as indicated in table 8.3.

Wet weather loadings are very difficult to control due to the number of sources and the magnitude of flow involved. This results in relatively few alternatives for the control of bacteria in wet weather. The most effective action would involve the elimination of

TABLE 8.3: WET WEATHER SIMULATION RESULTS - Bacteria

Objective	Alternative	Hour of Storm	STA.6 - Eglinton Ave. Existing Instream Count (#/100 ml)	STA.6 - Eglinton Ave. Simulated Instream Count (#/100 ml)	STA.3 - Bloor St. Existing Instream Count (#/100 ml)	STA.3 - Bloor St. Proposed Instream Count (#/100 ml)	Benefits
To reduce the potential for the presence of specific pathogens of human origin.	Eliminate combined sewer overflow from Black Creek	1 3 10	17188 18650 2147	17188 18650 2147	80772 19994 3288	17125 19994 3288	Reduced risk to the user of contracting a disease due to the reduced potential for the presence of specific human pathogens. Reduced industrial waste loadings. Reduced sediment contamination (which reduces the potential for future water column contamination due to resuspended sediments). Improved aesthetics.
To reduce the bacterial load from tributary reaches for water quality enhancement in the upper reaches of the river.	Implementation of retention ponds on Emery Creek, Berry Creek and Humber Creek.	1 3 10	17188 18650 2147	16648 17848 2253	80772 19994 3288	81641 19818 3316	Reduced metals load. Various efficiencies for bacteria removal (Rideau River Study). Additional implementation of an UV disinfection unit on the effluent weir would reduce bacterial load during dry weather. Reduced sediment contamination.
Dog and litter control.	Improved enforcement of by-laws.		Approximately 20% decrease of in-stream fecal coliform densities (Rideau River Study)				Reduced runoff bacterial loadings. Improved aesthetics. Contributes to the reduction in potential for pathogen input.

CSO to reduce the potential for discharge of specific human pathogens. Sediment contamination in the river would also be reduced. The reduced sediment contamination will in turn influence dry weather bacterial levels because less sediment will be available to associate with and resuspend bacteria. A reduction in aesthetic impacts due to sanitary discharges from outfalls and a reduction in industrial and hazardous waste loads will also be manifest with CSO elimination.

Dog and litter control bylaws also represent a viable means of reducing bacterial contamination of the river in wet weather. These controls should be enforced more effectively to reduce the runoff bacterial load and to improve aesthetics. The Rideau River Stormwater Management Study indicated that a decrease of up to 20% in in-stream FC densities was possible if dog and litter control regulations were effectively enforced.

Stormwater ponds are expected to be of some use in the control of bacteria during wet weather due to natural die-off and sedimentation during the retention period. In instances where ponds are implemented to reduce heavy metal contamination, design should also consider the need for extended retention to facilitate die-off. Further investigation of the potential for disinfection of retained stormwater is warranted.

8.3 SYNTHESIS OF WATER QUALITY FINDINGS

Although significant improvements in water quality can be achieved through a widespread program of controls, pollution of the Humber River from urban sources cannot be completely eliminated or brought within the Provincial Water Quality Objectives through the implementation of the controls considered. From a water quality view alone, it is therefore clear that all possible controls have to be implemented in order to achieve the maximum possible reduction in pollutant load to the Humber River. It is recognized, however, that

institution of all of the controls in each sewershed will not likely be possible. The endorsement of a specific control option within a given sewershed will depend upon the effectiveness of the option in relation to its cost, and its feasibility. Information on feasibility and costs will be provided in subsequent sections. The purpose of this section is to summarize the effectiveness of the various control options.

In an effort to synthesize the water quality information on metals, two water quality indices have been formulated. The first, termed the "PWQO Reduction Index" considers water quality stations on the main Humber only (9, 7, 6, 3). The index for individual stations and control options is determined by dividing the reduction in the hours of violation, by the hours of violation for the existing case. An index of 1.0 represents complete elimination of PWQO violation. The index at individual stations incorporates the impacts of all upstream controls. It is therefore possible to note an increase or a decrease in the effectiveness of an option, moving downstream, due to greater or fewer opportunities for application of the control. The second index, termed the "Load-Length Index" considers both the main Humber and tributary stations. This index was created by weighting the net load reduction in urban catchments tributary to the station, by the length of river downstream of the station. This procedure gives added weight to pollutant reductions in the upper part of the basin and therefore allows comparison of a small load reduction effecting the entire river, with a large load reduction effecting only the lower reaches. This index excludes the impacts of upstream sources of contamination and provides an indication of the relative utility of the different control options within each sub-watershed.

The formulation of numerical indices to summarize bacterial quality impacts is not practical. The effects of die-off as the bacteria are washed down the river makes the distillation of observed data into a single number misleading. The effects of control options on bacteria have therefore been summarized in a qualitative manner.

The PWQO Reduction Indices are presented in Table 8.4. Reading down the columns under each station will indicate the effect of applying a particular control option to land upstream of the station. Reading across the rows will indicate the increasing or diminishing impact of a particular control option, progressing downstream. The composite index and the composite index without Black Creek, indicate the overall impact of a particular control option if it is applied throughout the basin, or, everywhere except Black Creek, respectively.

Examining Table 8.4, it is evident that a major reduction in the hours of PWQO violations is possible for lead and zinc (97-98% and 80-85%). Similar reductions are not possible for copper because background concentrations of this parameter exceed the PWQO under most conditions. The composite index indicates that the most effective means of reducing PWQO violations is through the use of retention ponds. Industrial ponds will have the largest overall impact. It is evident, however, that the use of ponds in the northern industrial areas alone will have a diminishing impact moving downstream, as more and more residential land contributes to PWQO violations. In order to gain a substantial impact on violations, retention facilities are needed to control stormwater pollution from all sources, regardless of land use.

Street sweeping and catchbasin cleaning will have an effect on the PWQO Reduction index throughout the basin. In general, catchbasin cleaning is more effective than sweeping, accounting for about 80% of their combined index. Catchbasin cleaning alone will not have sufficient impact to produce major water quality benefits in the absence of retention facilities, but will be useful if applied in conjunction with ponds.

Roof leader disconnection will not have a major impact on PWQO violations for the metals. In general, the disconnection of roof leaders is not considered an effective control option and should be

TABLE 8.4 : PWQO REDUCTION INDICES

Parameter	Control Option	Station 9 (Sheppard Ave)	Station 7 (Lawrence Ave)	Station 6 (Eglinton Ave)	Station 3 (Bloor Street)	Composite Index	Composite Index without Black Creek Control
Lead	Hours spent in exceedence of PWQO (Existing Case)	133	263	351	802	379	-
	Industrial Ponds	.75	.64	.53	.39	.59	.49
	Street Sweeping & Catchbasin Cleaning	.11	.14	.19	.14	.13	.10
	Roof Leader Disconnection	.04	.03	.07	.07	.05	.03
	Residential Ponds	.08	.17	.19	.37	.20	.10
	Dry Weather Sources	0	0	0	0	0	0
	Total	.98	.98	.98	.97	.98	.71
Zinc	Hours spent in exceedence of PWQO (Existing Case)	79	186	263	642	285	-
	Industrial Ponds	.58	.47	.60	.28	.47	.39
	Street Sweeping & Catchbasin Cleaning	.11	.16	.01	.10	.12	.09
	Roof Leader Disconnection	.04	.04	.06	.07	.05	.03
	Residential Ponds	.11	.18	.19	.31	.20	.10
	Dry Weather Sources	0	.01	0	.03	.01	0
	Total	.85	.85	.86	.80	.84	.62
Bacteria (dry weather)	Elimination of priority outfalls	major impact	moderate impact	slight impact	major impact	significant overall impact	-
	Disinfection (Emery Creek)	major impact (but PWQO exceeded)	impact still apparent	impact still apparent	masked by direct storm sewer	-	-
Bacteria (wet weather)	Elimination of CSO	NA	NA	NA	Initial impact on in-stream counts diminishes as storm proceeds however, there is a large reduction in total load.	-	-
	Retention Ponds	slight impact in load reduction but stream FC count still exceeded PWQO	slight impact on loadings but PWQO exceeded	slight impact on loadings but PWQO exceeded	masked by direct storm sewer inputs		
	Elimination of priority outfalls	impacts unquantifiable but option reduces release of scoured fecal deposits					
	Dog and litter controls	impacts unquantifiable but previous studies suggest up to 20% reduction in FC load					

NB - an index of 1.0 indicates complete elimination of PWQO violations

implemented only where other benefits, such as flow reduction, are evident.

A program to eliminate dry weather sources of chemical contamination will improve water quality in the Humber River far more than is indicated by the index. During the period April 1985 to August 1985, MOE staff encountered numerous instances of "spills" from storm sewers during dry weather. During 17 field trips, 8 separate spills were encountered. Information on these spills has been presented previously in Table 6.7. It is noteworthy that this information was gathered in the course of routine field work and not as part of a spill detection program. The frequency of detection suggests that these were not isolated and accidental spills, but rather indications of widespread dumping of chemicals to storm sewers. If this is the case, then the Humber River is affected by dry weather sources to a far greater extent than indicated by the limited sampling program conducted through TAWMS or by summaries of reported spills. There is, therefore, a strong argument for the inclusion of expanded dry weather source detection and control as part of an overall strategy for improvement of the Humber River.

Comparing the two composite indices presented in Table 8.4, the importance of implementing control measures on Black Creek is evident. Black Creek is a major source of contamination for the lower reaches of the Humber River. Control options involving retention ponds will be difficult to implement on Black Creek because of the lack of suitable sites. Failure to control contamination from Black Creek however, will have significant impacts on the ability to improve the overall quality of the Humber River. From a water quality perspective, control of Black Creek is necessary.

In terms of bacterial contamination, it is evident that this is both a dry weather and a wet weather problem. Dry weather contamination can be ameliorated through a combination of disinfection at two sites (Emery Creek and Black Creek) and elimination of known priority outfalls. The elimination of the dry weather sources is

important to the reduction of counts in the lower portion of the basin. If the sources of contamination upstream of the priority outfalls cannot be traced and eliminated, then it may be advisable to intercept these sewers. In certain instances, on-line disinfection of a tributary (e.g. Emery Creek) may be a practical interim measure.

Wet weather bacterial contamination cannot be reduced to levels approaching the PWQO using the options considered. Mass loading of bacteria can be reduced by eliminating CSO and priority outfalls. The impact of these controls is generally short-lived in terms of in-stream bacteria counts, however, as too many bacteria are washed from uncontrolled areas during storms for the controls to have much effect. Stormwater ponds will have a small beneficial effect on FC load reduction. While ponds are not sufficiently effective to be warranted from a bacterial standpoint alone, the design of facilities implemented for heavy metal control should include consideration of bacterial die-off. Disinfection of stored wet weather flow should be considered. More effective enforcement of dog and litter bylaws may yield significant results in wet weather. Previous studies have suggested that a 20% reduction in FC load may be possible through effective administration of such bylaws.

Table 8.5 shows the "Load-Length Indices" for controls on the various urban sub-basins. Reading down the columns the indices demonstrate the effectiveness of a particular control within a specific sub-basin. Reading across the rows it is possible to assess the cumulative effect of a particular control.

In general, the indices suggest that the primary emphasis for controls should be on Emery Creek (above Station 12), the West Humber (above Station 8) and Black Creek (above Station 5). Postulated controls in these areas account for 73%, 79% and 67% of the total indices for lead, zinc and copper respectively. The contribution made to the indices by other portions of the Humber

TABLE 8.5 : LOAD-LENGTH INDICES

Parameter	Control Option	Implementation of Control Option Above STA. 12 (Emery Ck.)	STA. 9 (Sheppard)	STA. 8 (W. Humber)	STA. 7 (Lawrence)	STA. 6 (Eglinton)	STA. 5 (Black Cr.)	STA. 3 (Bloor St.)	Full Basin
Lead	CSO	0	0	0	0	0	.033	0	.033
	Industrial Ponds	.117	.003	.082	.058	.028	.099	0	.387
	Street Sweeping & Catchbasin Cleaning	.007	.012	.026	.011	.012	.046	.003	.115
	Roof Leader Disconnection	.001	.010	.008	.004	.009	.030	.002	.065
	Residential Ponds	.007	.025	.048	.017	.025	.091	.006	.219
	Dry Weather Sources	.003	0	0	0	0	.019	0	.023
	Total	.135	.050	.165	.089	.074	.318	.011	.841
Zinc	CSO	0	0	0	0	0	.057	0	.057
	Industrial Ponds	.066	0	.050	.029	.015	.050	0	.209
	Street Sweeping & Catchbasin Cleaning	.015	.007	.025	.012	.011	.014	.002	.086
	Roof Leader Disconnection	.001	.009	.009	.005	.009	.034	.002	.070
	Residential Ponds	.012	.015	.036	.013	.016	.062	.004	.157
	Dry Weather Sources	.018	0	.004	0	.001	.122	0	.147
	Total	.113	.031	.125	.058	.053	.338	.008	.725
Copper	CSO	0	0	0	0	0	.031	0	.031
	Industrial Ponds	.019	.001	.019	.012	.006	.012	0	.069
	Street Sweeping & Catchbasin Cleaning	.017	.011	.035	.016	.016	.011	.002	.109
	Roof Leader Disconnection	.002	.010	.015	.008	.014	.026	.002	.078
	Residential Ponds	.003	.007	.016	.007	.009	.015	.001	.059
	Dry Weather Sources	.003	0	.001	0	0	.026	0	.030
	Total	.045	.029	.087	.044	.045	.121	.006	.378

NB - a total, full basin index of 1.0 would represent complete elimination of urban load
- catchbasin cleaning accounts for 80% of the combined street sweeping and catchbasin cleaning index

River basin is fairly uniform. In order to achieve significant impacts after mitigating Emery Creek, the West Humber and Black Creek, it would be necessary to control runoff quality on virtually all minor tributaries to the Humber River.

The strategy for control of Emery Creek should include a retention facility together with enhanced catchbasin cleaning. In addition, special efforts should be made to eliminate dry weather sources of zinc and other contaminants. If the retention facility is sited near the confluence with the Humber River, control of both residential and industrial contaminants could be accomplished. Such a facility would also provide limited protection against accidental spills within this predominantly industrial catchment.

Mitigation of the sub-basins tributary to the West Humber would require a similar mix of controls, although there is not as much evidence for the need to control dry weather sources. Retention facilities will be the key element of the strategy, and the success possible will be primarily determined by the amount of catchment area which can be controlled by ponds. The land use mix on the West Humber catchments is such that combined control of residential and industrial areas will be necessary.

Control of Black Creek will require the implementation of programs to eliminate combined sewer overflows and dry weather sources, together with enhanced catchbasin cleaning. In order for a strategy to be truly effective, however, retention facilities for the control of stormwater runoff will be required. As in the case of the West Humber, the retention facilities would have to control a mixture of land uses. The extent to which the entire basin can be controlled will determine the relative success of mitigative actions taken to improve the lower Humber River. As has been noted previously, the availability of land will be a major problem on Black Creek.

8.4 FLOOD REDUCTION

Within the City of York the existing combined sewer system produces not only water quality degradation of both Black Creek and the

Humber River, but also basement flooding. Alternate methods of mitigating both problems have therefore been considered in this study. Analysis indicates that the options for reducing combined sewer overflows will not have major benefits relating to flood reduction, and vice versa. In this regard, several points should be made:

- Sewer separation will reduce basement flooding but is likely to produce little change and may even aggravate the water quality situation for some parameters. At present, combined sewer overflows contribute to the water quality problem and therefore elimination of overflows, would be a benefit. Sewer separation would eliminate overflows but would also significantly increase the amount of stormwater released, untreated, to the river. Since stormwater quality often approaches that of CSO, and since a large percentage of stormwater runoff receives treatment under existing conditions, sewer separation could actually have a negative impact on water quality for some parameters. Although sewer separation may remove some industrial contaminants and human pathogens, this option is not expected to produce major water quality benefits.

- Control of basement flooding through the use of local stormwater tanks will not have a significant effect on the number of combined sewer overflows. Local tanks would simply capture the volume of combined sewage which currently inundates basements. The use of local storage tanks may reduce the volumetric requirement of end of pipe overflow tanks slightly, but the overflow tanks will still be needed.

- The use of CSO outlet tanks to capture combined sewer overflows will not have any impact on basement flooding because the flooding occurs as a result of insufficient capacity in the local sewers rather than insufficient outlet capacity.

8.5 ECONOMIC IMPACTS

A cleanup of conditions affecting the Humber River will require a combination of the various control options considered in this

study. Since the implementation of all options will not result in complete mitigation of the water quality problems, any option which is feasible and which is considered cost-effective should be implemented. Information on effectiveness in terms of water quality improvement has been presented in previous sections. The estimated costs for each of the major control options are presented in this section.

It is recognized that the apportionment of funding responsibility will be a key issue in the successful implementation of a management plan. Cost sharing formulas may be more critical in certain instances than absolute costs. These issues are beyond the scope of this study and will be dealt with in detail as part of the plan implementation. The purpose of this section is to provide the information necessary to assess the cost-effectiveness of the various options.

Economic data are presented in Table 8.6. The costs provided for each control option are representative of the conditions modelled in the water quality analysis. The costs associated with industrial ponds for instance, correspond to the control of all industrial land within the urban Humber basin. It is recognized that feasibility considerations may limit the implementation of this or other options. Reduced implementation will lessen both the costs and the benefits of an option.

Certain assumptions have been made in estimating the costs of the various options, as below:

- o The cost of land has not been included in estimating values for retention ponds or CSO facilities. In general, any facilities would be constructed on public land. Estimates of typical land costs are provided separately in Table 8.7.

- o The costs associated with street sweeping and catchbasin cleaning represent the difference between the current costs of existing programs and the anticipated costs of an enhanced program.

TABLE 8.6 : COST SUMMARY OF CONTROL OPTIONS

Control Option	Description	Proposed Program	Cost ($000's) Capital	Annual	Present value
Do nothing	Existing case		-	-	-
Elimination of basement flooding using local storage tanks[5]	Flow control at local combined sewers (inlet restriction/ storage)	Inlet detention tanks	16600	50	17300
Sewer separation	Construct separate storm sewers to capture overland flow	Complete program presently underway	84700	-	84700
Elimination of combined sewer overflow[5]	CSO interception by detention tanks and diversion of detained flow to WPCP.	Eliminate overflow of annually recurrent storms with detention tanks.	4700	31	5040
Industrial ponds	Stormwater detention ponds for quality control of runoff from industrial landuse area.	Provide storage for 20 mm of runoff from industrial catchment area.	4400	56	5100
Enhanced street sweeping	Enhanced street sweeping with mechanical sweepers	Increase street sweeping frequency to three times per week.	3500[1]	1140[1]	16000[1]
Enhanced catchbasin cleaning	Catchbasin cleaning twice per year	Increase catchbasin cleaning frequency to twice the existing frequency	722[2]	275	3700
Roof leader disconnection	Disconnect roof leaders from sewers	Disconnect all roof leaders and discharge on to pervious surface	27000	-	27000
Residential ponds	Stormwater detention ponds for quality control of runoff from residential landuse areas	Provide storage for 20 mm of runoff from residential catchment area.	15100	96	16200
Elimination of dry weather sources	Eliminate sources of contamination at selected priority outfalls	Trace and disconnect sources of metals and bacteria.	-	600[3]	6600[3]
Disinfection	Disinfection of dry weather flow	Disinfection of dry weather flow with ultra-violet disinfection units.	300[4]	14	460

1 estimate only, to be confirmed; capital costs includes deferred capital costs

2 capital costs includes deferred capital costs

3 assumed cost of $150,000/municipality/year; does not include costs of physical disconnection

4 estimate only, cost may be higher dependent on site conditions

5 if both options were implemented, the total capital cost is $18.5M and the present value is $19.2M

TABLE 8.7 : CONTROL OPTION LAND COSTS

Location	Area (ha)	Total Cost ($1000)	Cost/ha ($1000)
CSO Facilities			
Black Creek (E. of Rockcliffe Blvd.)	1.7	12.9	7.4
Black Creek (W. of Rockcliffe Blvd.)	1.0	7.5	7.4
Black Creek (Hyde Ave.)	0.9	6.6	7.3
Humber Marsh (Berry Rd.)	0.4	3.0	7.5
Average	-	-	7.4
Retention Ponds			
Emery Creek (St. Lucie Dr. - Storer Dr.)	7.9	73.0	9.2
West Humber R. (Martin Grove Rd.)	3.5	26.1	7.5
Main Humber R. (Norfield Cres. near Albion Rd.)	3.7	37.0	10.0
Average	-	-	9.0

- AVERAGE LAND COST: $8,700/ha
- COMBINED SEWER OVERFLOW OPTION
  - To provide 51,000 m^3 of tank storage at Hyde Ave. and E. of Rockcliffe.
    land cost at approximately $7,400/ha
    land area of 2.64 ha
    cost: $20,000
- RESIDENTIAL PONDS
  - Average land cost: $9,000/ha
    pond area of 50.2 ha
    cost: $452,000
- INDUSTRIAL PONDS
  - Average land cost: $9,000/ha
    pond area of 29.1 ha
    cost: $262,000

Source: Estimates by MTRCA

- Annual operation costs for retention facilities allow for routine maintenance only and do not include extraordinary costs such as treatment of captured spills.

- All present value costs are based on a time horizon of 20 years and a discount rate of 7%. Salvage values for options with greater life expectancies have not been included.

Referring to Table 8.6 the most costly schemes include disconnection of roof leaders, enhanced street sweeping and sewer separation. These options do not produce major water quality benefits. Enhanced catchbasin cleaning appears to be a low cost option which will have definite water quality benefits. The cost of providing ponds to control industrial areas is comparable to the cost of controlling CSO overflow. The cost of residential ponds is 3 to 4 times the cost of industrial ponds because of the larger catchment area controlled.

The potential land costs associated with combined sewer overflow tanks, industrial ponds and residential ponds may alter the anticipated costs of these options. The estimated land costs are not sufficient, however, to alter the relative ranking from an economic point of view. When both costs and option effectiveness are considered the importance of these land costs becomes insignificant.

8.6 FEASIBILITY OF IMPLEMENTATION

The feasibility of control option implementation will be perhaps the most critical aspect in the execution of a management plan for the Humber River. Technical and political constraints could severely limit the utility of several of the control options. Public acceptance of the concept of river improvement may not extend to acceptance of certain control options. A summary of the constraints associated with each of the major control options is presented below.

Elimination of CSO

It is anticipated that this option will generate limited public and political opposition. Reduction of combined sewage discharge to the rivers is a well established goal for both municipal and provincial governments and it is anticipated that this option will receive widespread public support. Technically, the practical elimination of CSO through the use of covered overflow storage tanks appears feasible. It is unlikely that the option will have detrimental impacts on other uses such as recreation (parks) or flood control. The only significant drawback to this option is that it is not a particularly cost-effective means of controlling metal contamination. The cost-effectiveness of this option must be established based upon the elimination of bacterial and pathogenic contamination, hazardous contaminants and accidental spills. It is a relatively costly option and extensive discussions relating to funding are expected.

Industrial Ponds

Industrial ponds represent the most cost-effective means of significantly reducing metal loads to the Humber River. Technically, it appears that there are several possible sites which are suitable in the northern portion of the basin. A lack of clearly identifiable sites on Black Creek may reduce the possible benefits of this option.

Opposition to the use of industrial pond controls may be expected to be moderate to high from municipal governments and the public. Municipal and public concerns will relate primarily to aesthetics, the loss of open space and safety. Decisions regarding the operating agency for ponds will have to be made.

Street Sweeping

Enhanced street sweeping programs are not expected to raise severe opposition from the public. The main impediment to the implementation of this option will be its very low cost-effectiveness. Municipalities bear sole responsibility for the costs of street sweeping. It is unlikely that they will be prepared

to expand existing programs without additional funding. The Province is unlikely to place a high priority on street sweeping because of its limited impact on water quality.

Catchbasin Cleaning

An augmented catchbasin cleaning program is not likely to produce significant opposition. Such a program has few drawbacks and has been demonstrated to be both effective and relatively inexpensive.

Roof Leader Disconnection

A program of roof leader disconnection or diversion to pervious areas is likely to be administratively difficult and potentially unpopular. From an administrative perspective, the need to ensure that all roof leaders are diverted to lawns, and that they remain so over time, will require additional staff. Since the roof leaders will usually be located on private property, enforcement will likely be a problem. Public acceptance of such a program is not likely to be strong because of perceived inconvenience. The disconnection of roof leaders in industrial areas is not considered appropriate since it would be difficult to prevent discharge to paved areas.

Residential Ponds

As in the case of industrial retention ponds, there is likely to be severe opposition to this option from the public and municipalities. The arguments against implementation will be the same, namely impairment of aesthetics, loss of parkland, and safety. Due to the greater safety hazard associated with ponds in residential areas it is likely that this option will be the most contentious of those considered.

Technical problems relating to the large number of storm outfalls and the lack of suitable pond sites will make widespread implementation of this option difficult. The water quality results have indicated, however, that ponds in residential areas are necessary if a significant cleanup of the Humber River is desired.

Dry Weather Source Control

Dry weather contamination from storm sewers occurs for a variety of reasons, including: illegal connections, permissible discharges in excess of the PWQO, accidental spills, and illicit dumping. In order to significantly reduce the problem of dry weather sources, it will be necessary to trace and disconnect illegal connections and to revise existing by laws which permit discharge of relatively high concentrations of contaminants. In instances where tracing and disconnection have been shown to be ineffective it may be necessary to intercept and treat the dry weather flows from certain priority outfalls. Regular monitoring of sewer outfalls will be needed to ensure compliance with the revised by laws and to reduce the occurrence of illicit dumping. It is recognized that a full program of dry weather source control will be difficult, both administratively and technically. Continuous enforcement and monitoring will require additional municipal staff. In the case of bacterial control it may be advisable to use in-stream disinfection as an interim measure to ensure rapid reduction of bacteria loads in the highly contaminated tributaries.

Despite the difficulties associated with this option, it should be recognized that the benefits of ongoing dry weather control will extend far beyond the cleanup of metal and bacteria contamination. There is mounting evidence that illicit dumping of a variety of substances occurs quite frequently in the Humber River basin. Retention ponds will assist in the containment of settleable or floating contaminants but they cannot control dissolved pollutants. Appreciable cleanup of the Humber River cannot be expected unless regular "spills" can be eliminated.

8.7 CONTROL OPTION SELECTION

Each of the control options considered have been discussed in terms of water quality criteria, economic impacts and ease of implementation. On the basis of this information it is possible to select options which should be considered for inclusion in the Humber River Management Plan.

It is apparent from the results of this study that although significant improvements may be made, it may not be possible to bring the Humber River within the Provincial Water Quality Objectives for either metals or bacteria. All options which will contribute significantly to water quality improvement and which are cost-effective and feasible, both technically and in terms of acceptance, should therefore be included in the Management Plan for the Humber River.

The selection of a combination of control options to achieve the desired results on the Humber River is difficult because of the complexity introduced by the need to consider the ease of implementation as well as effectiveness and costs. Table 8.8 summarizes information on water quality impacts, costs and implementation considerations for each option. The options are ranked under each category and a summary ranking is provided at the end of the table. The summary ranking represents a subjective judgment which combines quality, cost and feasibility. The primary purpose of this ranking is to define those options which may be implemented immediately, those which should be considered for implementation and those which may be discarded as ineffective.

Referring to Table 8.8, it is possible to group the control options based on the summary ranking. Group 1 would include the three control options with the highest rank: Elimination of Combined Sewer Overflow, Enhanced Catchbasin Cleaning, and Elimination of Dry Weather Sources. It is noteworthy that a program to eliminate dry weather sources at priority outfalls is currently underway. The other options have received extensive study. This group is characterized by established technical feasibility and the likelihood of general acceptance by the public. The options in this group have a demonstrated cost-effectiveness for at least one water quality parameter. It is anticipated that Group 1 options could be implemented quickly, if issues relating to funding can be resolved.

Group 2 would include the next three options: Industrial Ponds, Disinfection, and Residential Ponds. This group of options is critical to the success of a management strategy on the Humber

TABLE 8.8 : CONTROL OPTION ATTRIBUTES

WATER QUALITY	Do Nothing	Local Storm-water Storage	Sewer Separation	CSO Tanks	Industrial Ponds	Enhanced Street Sweeping	Enhanced Catchbasin Cleaning	Roof Leader Disconn.	Residential Ponds	Elimination of Dry Weather Sources	Disinfection
PWQO Reduction Indices											
Lead	0	0	-	-	.590	*	.130	.050	.200	0	0
Zinc	0	0	-	-	.470	*	.120	.050	.200	.010	0
Bacteria (dry weather)	0	0		-	Polishing	-	-	-	Polishing	Local Impact	Major Impact
Bacteria (wet weather)	0	0	Minor Impacts (pathogens)		Load Reduction	- -	- -	-	Load Reduction	Local Impact	-
Load-Length Indices											
Lead	0	0		.033	.387	*	.115	.065	.219	.023	0
Zinc	0	0		.057	.209	*	.086	.070	.157	.147	0
Copper	0	0		.031	.069	*	.109	.078	.059	.030	0
ADDITIONAL BENEFITS	-	-	Elimination of some industrial pollutants	-	Spill Capture	Aesthetics	Aesthetics		Spill Capture	Reduction of illicit dumping	
RANKING											
Metals	10	9	8	6	1	7	3	4	2	5	10
Bacteria	6	6	6	1	4	6	6	6	5	2	3

* A combined index was produced for street sweeping and catchbasin cleaning. Catchbasin cleaning accounts for the majority of the improvement (80%)

TABLE 8.8 (cont'd)

	Do Nothing	Local Storm-water Storages	Sewer Separation	CSO Tanks	Industrial Ponds	Enhanced Street Sweeping	Enhanced Catchbasin Cleaning	Roof Leader Disconn.	Residential Ponds	Elimination of Dry Weather Sources	Disinfection
FLOOD REDUCTION	None	Complete	Complete	None	None	None	None	None	None	None	None
ECONOMICS											
Capital Cost	0	16.6	84.7	4.7	4.4	3.5	0.72	27.0	15.1	0	0.3
Annual Costs	0	50	0	31	56.0	1140	275.0	0	96.0	600.0	14.0
Present Value	0	17.3	84.7	5.0	5.1	16.0	3.7	27.0	16.2	6.6	0.46
Ranking	1	1+	2+	4	5	8	3	9	7	6	2
IMPLEMENTATION											
Technical Constraints	-	design considerations		design considerations	lack of land, design considerations	None	None	potential ponding on streets, lawns	lack of land, design considerations	source tracing	None
Public Acceptance	low	medium	high	high	low	high	high	medium	low	medium	medium
Municipal Accept.	low	medium	high	low	low	medium	low	low	low	medium	high
Provincial Accep.	low	medium	low	high	high	low	high	low	high	high	medium
Ranking	9	2+	1+	1	7	5	2	8	6	3	4
SUMMARY RANKING	8	1+	2+	1	4	7	2	9	6	3	5

+ not ranked with quality options

NB - Capital Costs and Present Values are in millions of dollars. Annual Costs are in thousands of dollars.

River. If none of the elements of group 2 are implemented, significant improvement of in-stream water quality will not occur. It is likely that there will be severe constraints on the implementation of this group. Technical feasibility will need to be established on a case by case basis, and strong opposition may be anticipated from various sectors. It is anticipated that these options will have to be phased in over an extended period, with more detailed studies, pilot scale tests, and environmental and public hearings forming a major part of the implementation strategy. The degree of success achieved in implementing each of these options across the entire basin will determine the effectiveness of the management strategy.

Group 3 would include Roof Leader Disconnection and Enhanced Street Sweeping. This group of options is characterized by limited effectiveness in terms of water quality improvement and high costs. In general, these options should be implemented only on a limited scale, on a case by case basis, where ancillary benefits are evident. Widespread implementation of these options will not yield significant water quality benefits.

Table 8.8 contains two options which would eliminate basement flooding. As discussed previously, neither of these options will have major impacts on water quality. The decision to select one option over the other for inclusion in the management plan may be made based on economic and feasibility considerations alone. Based upon economic considerations it would appear that flood control using local stormwater detention tanks is superior to sewer separation.

8.8 BENEFIT EVALUATION

The Humber River Management Plan will include, to some degree, all of the Group 1 and 2 options selected in Section 8.7, together with the options selected during the prescreening described in Chapter 7. Many of the available options can be adopted in varying degrees. In order to determine how far the program for water quality control should be taken, it is necessary to examine the

benefits anticipated and the uncertainties involved. The benefits which will be achieved through the implementation of a management plan must be considered in terms of the current uses made of the river and the possibility of improving or allowing new uses in the future. In this regard there are three primary areas of consideration: Public Health, Fisheries, and Other Uses.

8.8.1 PUBLIC HEALTH

Public Health concerns on the Humber River relate primarily to the potential for disease or infection among swimmers and waders in the urban and rural portions of the basin due to inputs of fecal wastes. In addition, the Humber River's contribution to problems of the western beaches is a cause for concern. From a public health perspective the management plan should, therefore, reduce the potential for the presence of specific human pathogens.

This study analysed fecal coliform, an indicator of fecal pollution and associated pathogens. In practical terms, a reduction of fecal coliform (FC) bacteria counts in-stream, as well as FC loads to the lake, will reduce the risk of pathogen presence. A geometric mean value of 100 FC/100 ml (PWQO) is the stated objective; however, it should be recognized that the true goal is a reduction in the probability of pathogen occurrence. Therefore, even partial FC reductions which do not reach the PWQO are beneficial.

The options which will act to reduce fecal contamination include: Reduction of CSO, Dry Weather Source Controls, Dog and Litter Controls, Rural Controls, Disinfection, and Stormwater Ponds. Each of these controls differ in their relative impact on dry and wet weather contamination and on the stream areas effected.

Reduction of CSO is highly effective in reducing a potentially major source of human pathogens through the removal of human fecal wastes during wet weather. The option is applicable only to a cluster of overflow points on Black Creek and will therefore only have impacts on the lower reaches and the loadings to Lake Ontario. Although it is recognized that reduction of FC to the PWQO in wet weather is not

likely to be achieved and hence swimming potential will not be significantly improved, however, the elimination of human fecal wastes is considered a major benefit in terms of public health. CSO reduction will also reduce potential dry weather fecal contamination due to an overall reduction in sediment contamination.

Dry weather source control as it relates to public health consists primarily of mitigation of illegal sanitary connections to storm sewers. There are various means of accomplishing this option, ranging from tracing and disconnecting the illegal sources to interception of the known dry weather sources at the end of the pipe. Disconnection is preferable because it will reduce FC counts in dry weather and the scour of deposited fecal wastes in wet weather. Tracing of bacterial sources is a difficult task, however, and it will be useful to intercept and treat dry weather flows from known problem sewers in cases where tracing and disconnection are not totally successful. Mitigation of dry weather sources will have effects throughout the basin, but because of the location of known priority sewers, the most notable impacts will be achieved in Emery Creek, Black Creek and on the main Humber below the Black Creek confluence. Dry weather source controls are expected to produce a major reduction in potential pathogenic contamination and will reduce FC loads to the river and the lake during dry weather to the point where the PWQO is expected to be achieved below Bloor Street. The importance of dry weather controls is stressed by the fact that dry weather conditions prevail most of the time throughout the summer period, because of the short duration of runoff events.

Dog and litter controls are expected to be moderately effective in reducing the buildup of FC bacteria on the urban catchment. Although the degree of success anticipated is difficult to quantify, the basin-wide nature of this control option may produce significant results. The Rideau River Stormwater Management Study suggested that in-stream FC density reductions of up to 20% might be achieved using this type of control. Since the means available for reducing wet weather FC loads are limited, application of this option is warranted from a public health perspective. The primary benefits will include a reduction of FC loads during wet weather, improved

public awareness of the impact of humans and domestic animals on the river, and improved aesthetics in urban areas which receive fecal deposits.

Rural controls relating to public health include a wide range of activities involving livestock access to rivers, manure handling, illegal connections to tile drains, and improperly designed or operated septic systems. The impact of rural controls will be restricted to the upper portions of the urban Humber and the rural Humber above Steeles Avenue. The effectiveness of control measures is difficult to quantify, but may be quite significant because of the large area involved. Rural controls will reduce FC loads to the river during both wet and dry weather, although it cannot be predicted whether FC densities can be reduced to PWQO levels under either condition. The presence of closed swimming areas in the upper basin is sufficient grounds to warrant rural control efforts.

Disinfection of dry weather flows using ultraviolet (UV) radiation has the potential to be a highly effective means of reducing dry weather FC densities at selected locations. The option is technically feasible and cost-effective, but has disadvantages from an implementation view because of the implications of treating a watercourse. It should be regarded as a secondary or interim measure for use in controlling major source areas while other forms of control are pursued. The option is technically flexible and may be useful in many special cases. There is little available field experience with in-stream UV disinfection but its high potential warrants at least field scale testing of the option. If disinfection of dry weather flows proves practical, major reductions in FC loads from tributaries are possible. Disinfection has the advantage of treating all in-stream bacterial inputs including dispersed or low level sources. Its effectiveness is, therefore, expected to be greater than the other dry weather options which are aimed at major definable sources only.

Stormwater ponds are expected to have only a limited impact from a public health point of view. Pond controls may delay and reduce wet weather bacterial loads through sedimentation and die-off of

bacteria. The effectiveness of this option has been quite variable in other studies, however, and it is felt that ponds should be combined with disinfection of retained stormwater in order to be effective in terms of bacterial load reductions. Disinfection of retained stormwater has received limited testing, and field evaluation of this option would be necessary to verify its utility. Stormwater, at present, is a virtually uncontrollable source of bacterial load and as such, the use of ponds in conjunction with disinfection is considered a potentially useful option which should be investigated further through field applications. Since ponds may have other benefits with respect to fisheries, their inclusion in a test program aimed at reducing wet weather bacterial loads is warranted.

8.8.2 FISHERIES

Fisheries concerns on the Humber River centre on the state of the existing fishery and the potential for preserving and improving the fishery as an urban resource. The Humber River fishery consists of a resident cold water fishery in the upper basin, a warm water fishery in the middle Humber and a combination of migratory cold water and resident warm water fish in the lower reaches.

There is a demonstrated demand for an urban fishery in the Humber River as evidenced by the number of anglers and the current fish stocking programs to meet this demand. There are preliminary expressions of interest in the Humber Fishery from MNR, MTRCA and some private groups. Major limiting factors in improving the fishery include the presence of barriers, poor habitat and poor water quality. Major investments in habitat improvements will not be made unless water quality violations and sediment loads are reduced. MNR may consider the Humber River for further programs if there is a commitment for water quality to be improved. The demand is sufficient to warrant action to prevent further degradation and upgrade water quality of the Humber River.

Fish in the Humber River appear to survive under existing conditions (except in Black Creek) although studies indicate that they are under stress and may be subject to sublethal effects. Tests conducted by MOE showed that fish exhibited an avoidance reaction to Humber River water collected after a storm. As is typical of the Humber River after runoff, the water contained concentrations of lead, zinc, copper and cadmium in excess of the PWQO. Heavy metals were the most common source of PWQO violations during the sampling programs conducted on the Humber River. There is reason to believe that elevated metals levels contribute to stress on the fishery, although there may be other factors involved. The reduction of metal concentrations is a primary objective to fisheries preservation and enhancement in the Humber River.

The control options which will have an effect on the water quality relating to the urban fishery include: Catchbasin Cleaning, Elimination of CSO, Dry Weather Source Control (both continuous permitted discharge and illegal dumping), Household Hazardous Contaminants Control, Sediment Control, and Stormwater Ponds (in both existing and new developments). The majority of these control options are aimed at reducing wet weather loads of metals which is the most serious concern from a fisheries view.

<u>Enhanced Catchbasin Cleaning</u> is expected to be moderately effective in reducing metal loads to the receiving water during wet weather. It will have a variable effect on the reduction of sediment and the different metals, reducing lead loads by about 15% and zinc and copper by smaller amounts. The impact of this option will be felt basin-wide within the urban Humber, but implemented alone, it will have only minor effects on in-stream water quality. Its relative ease of implementation and general cost-effectiveness make it an important option, especially in areas where end of pipe controls are not possible. Catchbasin cleaning will reduce metals input to all sections of the urban Humber, improving the quality of both the main branch and tributaries. The metals removed will tend to be those associated with particulates. Further study is required to assess the effects of particulate-associated metals removal on the fishery.

Combined sewer overflows are a source of heavy metals, industrial wastes, and hazardous contaminants during some wet weather events. Each class of pollutant will add to the stress on the urban fishery. The CSO may contain a higher proportion of dissolved metals compared to stormwater and may, therefore, have a more toxic effect on fish. The overall impacts of CSO generated metals are expected to be relatively minor, however, because there are few overflow points compared to the large number of storm outfalls. The main benefit of CSO elimination from a fisheries standpoint will be a reduction in the incidence of industrial wastes and hazardous contaminants in the river. Industrial wastes and hazardous contaminants have the potential to produce intermittent fish kills and the contaminants can accumulate in fish tissues. This is particularly significant in the Humber because the CSO occur upstream of Old Mill, an important site for sports fishing.

Dry weather sources of some metals and industrial wastes produce localized stresses in various portions of the urban Humber. There appear to be two main problem areas. First, permitted discharges to storm sewers are an order of magnitude above the PWQO for most metals, under existing bylaws. The current municipal bylaws are based on the MOE/MEA Model Sewer Use Bylaw which is in the process of being revised to include more parameters. It should be recognized that a model bylaw cannot account for the prevailing conditions in specific streams. In the Humber River, where metal violations occur regularly, there is reason for more stringent control of permitted discharge. This is particularly true for dry weather sources because of the limited dilution provided under low flow conditions.

The second problem area involves illicit dumping or improper disposal of industrial wastes and by-products. A distinction should be made between this problem and that of spills which are accidental. Illicit dumping and improper disposal results in unreported contamination of the watercourse. During the TAWMS study, MOE staff observed instances of unreported contaminant discharge with a regularity which precludes the possibility of accidental spillage as a cause. The impacts of dumping have not been quantified, but the problem is regarded as serious. Fish kills could result from the

introduction of certain contaminants, and stress on the fishery almost certainly occurs.

Mitigation of dry weather sources of metals and industrial wastes will require two different levels of action because of the two distinct problems. Revised sewer use bylaws may be used to reduce the level of metals legally discharged to storm sewers. Inspection and sampling are implicit in any bylaw revision and a list of priority outfalls with high metals concentrations has been prepared to assist in this regard. Control of illicit dumping and improper handling of wastes will require a program of industrial education, inspection, regulation, and enforcement.

The benefits of dry weather source control of metals and industrial wastes is difficult to quantify. In general, reduction of metals concentrations in permissible discharges will result in localized improvements in the ambient water quality, reducing chronic stress. Whether this will result in significant improvements to the fishery is unknown. Metals concentrations are generally not above the PWQO (except for copper) at most locations on the Humber during dry weather and many species of fish can acclimatize to elevated levels of metals. Some metals such as zinc can reduce the reproductive capability, however, and reduction of continuous dry weather discharges may, therefore, improve spawning at specific locations. The benefits of a reduction in the incidence of dumping or washing down of industrial wastes has the potential to have a strong beneficial effect on the existing fishery. The intermittent nature of these industrial discharges does not allow fish acclimatization and the effects may be severe depending on the chemicals present.

<u>Household hazardous contaminants</u> have a potential to impact the fishery in a manner similar to the dumping which occurs from dry weather industrial sources. Household contaminants are discharged to the storm sewer system throughout the urban Humber and although the individual releases are small, some contaminants may produce localized acute effects on the fishery. The impacts of household contaminants may be felt during dry weather, although the majority of HC's are probably flushed from the sewer system during wet weather.

The control of household hazardous contaminants will involve a public education program, together with a municipal collection and disposal program. The public education program is likely to have benefits beyond the control of household wastes as residents are made aware of their ability to produce adverse impacts on the river. From a fisheries view, the reduction in household pollutant discharge is likely to reduce accumulation of contaminants in fish and to limit the potential for intermittent acute toxic impacts.

Sediment control programs in the Humber River are expected to be important to preserving and expanding the Humber River fishery. High sediment loads have been cited as one reason for the lack of effort in habitat improvement in the Humber. High sediment loads can destroy habitat and disrupt spawning activity. In general, sediment is flushed from the Humber River on an annual basis, resulting in accumulation in the Humber Marsh and Bay areas. Accumulated sediment tends to be a sink for toxic substances.

Sediment control programs must be multi-faceted to be effective. Agricultural contributions can be reduced by alteration of cropping and plowing practices and the use of buffer strips. Streambank erosion can be reduced through stormwater management techniques (to reduce peak flows) and the rehabilitation of erosion prone sites. An important aspect in sediment control involves reduction of loads from new construction through the use of sedimentation ponds, buffer strips and other site controls.

Sediment control programs will reduce the sediment load in the Humber, improving fisheries habitat. A reduction in the sediment load will render the Humber River a more suitable choice for funding under fisheries improvement initiatives.

Stormwater retention ponds represent potentially the most effective means of reducing metals input to the Humber River. In order to achieve a maximum impact on metals delivery, stormwater ponds must control discharge from industrial, commercial and residential landuses, although priority should be given to industrial control. In areas of existing development, suitable sites are limited and are

in general currently used for other purposes, such as open space or parkland. In new developments, land is available for ponds and stormwater retention may be more easily implemented.

The benefits of stormwater ponds have been demonstrated in this study in terms of their ability to reduce in-stream peak concentrations and PWQO violations for metals. A basin-wide implementation of stormwater retention facilities would produce significant improvements, but would not completely eliminate PWQO violations. Linking reductions in concentrations, at levels which still exceed the PWQO, to specific fisheries benefits is difficult. Evidence exists that fish are stressed by metals in the Humber River but many other factors may be affecting the fish. It cannot be demonstrated that the fishery will be improved if stormwater ponds are implemented. Although ponds will reduce the amount of time the river is in exceedence of the PWQO, it should be noted that the primary reduction in metals will be in terms of the particulate associated fraction, while fish may be more severely affected by the dissolved constituents. Further study, preferably on a field scale, and incorporating other fisheries initiatives such as habitat improvement, are needed before the real benefits of stormwater retention can be defined for the Humber River fishery.

The substantial potential for metals reduction inherent in the stormwater pond option must be considered in conjunction with anticipated difficulties in implementation and the uncertainties in the probable fishery benefits. In relation to existing developments, the difficulties in finding suitable pond sites which do not conflict with other uses indicates the need to proceed slowly. The potential benefits and the need to better understand the impact of stormwater control on the fishery argues for at least pilot scale testing of the option. A phased approach is therefore envisioned for stormwater ponds in areas of existing development. During the first phase, a test facility will be constructed on Emery Creek near the confluence with the Humber River. The facility will be designed and operated to maximize metals removal from the predominantly industrial catchment to the north. Studies will be conducted to monitor water quality improvements and identify impacts on the local

fishery. Habitat rehabilitation and improvement will be undertaken in conjunction with the pond construction in order to determine the degree to which the fishery can be improved through a combined water quality and physical habitat improvement program.

The benefits to this approach are numerous. The test pond will exert control over one of the worst industrial catchments on the Humber River, reducing metal loads and providing a degree of protection against spills. The facility will provide a proving ground for the design and operational characteristics of stormwater retention facilities and will allow evaluation of additional options such as disinfection of retained stormwater. Finally, the commitment to undertake stormwater retention as a means of improving water quality will provide an impetus for the evaluation of improving fisheries habitat in the Humber River. This will allow a better quantification of the anticipated benefits which would accrue to a combined program of water quality improvement and habitat rehabilitation throughout the Humber River basin.

The second phase envisaged would entail construction of additional stormwater retention ponds at other sites throughout the Humber River basin. Efforts would concentrate on controlling discharges from industrial catchments initially, but would gradually be expanded to include stormwater control at all suitable sites in the Humber River basin. The decision to proceed with phase 2 would be contingent upon a demonstrable improvement in the fishery in the vicinity of Emery Creek.

A similar phased approach would be adopted for stormwater retention facilities in new developments in the upper Humber above Steeles. Because of the less stringent restrictions on available land, however, it may be possible to operate more than one test facility. Ideally, the test sites should also incorporate other water quality control methods, such as swale drainage or infiltration which are appropriate to new development but are difficult for retro-fit situations. The benefits of this approach are similar to those for existing development, with the additional benefit of reducing the impacts of developments and thereby preventing further degradation

of the Humber. It is noteworthy that there is a need to evaluate the effectiveness of ponds in both existing and newly developed environments because there may be significant differences, especially in terms of sediment design capacity and maintenance requirements.

8.8.3 OTHER USES

Although the principal uses of the Humber River may be examined within the context of public health and fisheries, there are other, less direct, uses which should be considered. Principal among these are: preservation of the lake as a source of drinking water, reduction of total phosphorus and suspended solids loads as per IJC criteria, protection of the Humber Marsh as an environmentally significant area, and improvement of aesthetics throughout the Humber River basin to enhance recreational opportunities.

The Humber River is only one of many sources which may impact on the quality of Lake Ontario and more specifically on the source of Toronto's drinking water. Nevertheless, the majority of contaminants introduced to the Humber River are flushed from the river system and accumulate in Humber Bay and the lake. Most of the control options which will improve conditions in the Humber River will also produce benefits relating to long term preservation of the drinking water supply. In particular, the elimination of CSO, dry weather source control of industrial discharge, and control of household hazardous contaminants will reduce the quantities of toxic substances introduced to the lake. Catchbasin cleaning and stormwater retention will reduce the loadings of heavy metals. Sediment controls and controls on agricultural operations will reduce the problems associated with sediments and nutrients introduced to the lake. While it is not possible to quantify the benefits of these controls on the future of the drinking water supply, it should be recognized that actions taken to improve the Humber River will have a positive effect on the lake and, therefore, the water supply.

The Humber River Marsh, located below Bloor Street, is considered a valuable wetland with a potential for aquatic and wildlife habitat. MTRCA has identified the area as an Environmentally Significant Area for planning purposes, although the designation is not formal. The marsh accumulates contaminated sediment washed from the Humber River watershed and, although sediment concentrations of most parameters are low, elevated levels of lead, cadmium, and chromium have been noted. Sediment and pollutant accumulation may have an impact on the marsh ecosystem and upstream source controls are, therefore, required to reduce loads.

Most of the control options directed towards fisheries improvement will also have a beneficial effect on the marsh. In particular, catchbasin cleaning and stormwater ponds will be effective in reducing particulate associated urban pollutants such as lead. Control of agricultural cropping practices and sediment control programs will reduce the sediment load and the opportunity of sediment associated pollutant accumulation. Control of dry weather sources of industrial wastes and household hazardous contaminants will limit the toxic substances available for accumulation in the marsh.

The valley of the Humber River is a valuable urban resource for passive recreation. Enjoyment of the resource is diminished by the degradation of aesthetics caused by the accumulation of litter and debris, washed from the watershed during runoff. Concern over this degradation has caused the implementation of initiatives such as the SCOUR (Students Cleaning Our Urban Rivers) program during the summer of 1985.

Many of the control options considered for public health and fisheries reasons will have ancillary benefits in terms of aesthetics. The control of CSO will reduce the amounts of sanitary paper directed to the watercourse. Enhanced catchbasin cleaning and stormwater ponds will reduce the amount of debris and litter transmitted. Stormwater ponds will incorporate skimming devices which will limit the introduction of floating solids and oil films. Litter control programs will reduce the accumulation of debris on the urban catchment, thereby limiting washoff of this material during storm events.

9. HUMBER RIVER WATERSHED MANAGEMENT PLAN

The discussion under the headings of Public Health, Fisheries and Other Uses, have indicated the benefits associated with the control options considered in this study. The options available vary in their effectiveness, costs, ease of implementation and the range of problems they will address. In addition, the options differ in the degree to which their benefits can be quantified and the uncertainty associated with the direct benefits which will accrue to different levels of water quality improvement. Certain options will provide multiple benefits and can be implemented easily at relatively little cost. Other options have great potential but may be difficult to implement, involve high costs, or require further study to demonstrate the actual benefits that will accrue. For this reason a staged approach is recommended for the management plan. During the first phase, which will extend up to five years, clearly beneficial and cost-effective measures will be implemented. Options which have a significant potential, but which require further evaluation will be implemented on a pilot scale. Monitoring of the impacts of both basin-wide and pilot scale options will be conducted throughout the initial phase.

Phase 2 will involve expansion of proven options across the watershed to achieve the maximum practical degree of water quality improvement. Only those options for which there are demonstrable benefits in the pilot scale tests and those options which address problems which have not been adequately dealt with by Phase 1 options will be implemented in Phase 2.

A summary of the proposed management plan is provided in Tables 9.1 and 9.2. The options, available cost data and anticipated benefits are provided for each phase.

TABLE 9.1 : HUMBER RIVER MANAGEMENT PLAN - PHASE 1

Option	Cost*	Scale	Effects	Benefits
1. CSO Control	$5.0	Black Creek	o reduces a potentially major source of human pathogens. o reduces input of industrial wastes and heavy metals and other hazardous contaminants. o reduces input of sanitary wastes.	o lessens public health risk. o reduces stress on fishery in the lower reaches. o reduces source of contamination for Humber Marsh and the lake (drinking water supply). o improves aesthetics, enhances recreational enjoyment.
2. Flood Reduction (local detention tanks)	$17.3	City of York	o upgrades level of protection to approximately 10 year design level.	o reduces frequency of basement flooding.
3. Catchbasin Cleaning	$3.7	Basin-wide	o reduces metal input to river at all points. o reduces input of litter and debris.	o reduces stress on the fishery throughout basin. o provides impetus for investigation of fisheries improvement programs. o reduces metal load to Humber Marsh and the lake. o improves aesthetics, enhances recreational enjoyment.
4. Dry Weather Sources (sanitary connections)	$6.6	Priority outfalls	o reduces potentially major source of human pathogens. o reduces FC loads in dry weather.	o lessens public health risk. o PWQO achieved in the lower reaches during dry weather.
5. Dry Weather Sources (permitted discharge)	NC	Industrial areas, Priority outfalls	o reduces dry weather input of metals and other toxic parameters. o reduces dry weather loads to lake.	o provides localized improvement in fishery habitat (spawning). o reduces pollutant accumulation in the marsh and lake.
6. Dry Weather Sources (dumping and poor handling of wastes)	NC	Industrial areas	o reduces frequency of discharge of industrial wastes and toxic contaminants.	o reduces potential for acute stress to the fishery. o reduces pollutant accumulation in the marsh and lake.

* Present value in millions of 1985 dollars, NC - Not Costed

TABLE 9.1 (cont'd)

Option	Cost*	Scale	Effects	Benefits
7. Household Hazardous Contaminants	NC	Basin-wide	o reduces intermittent discharge of acute toxic substances. o reduces toxic loads to the lake.	o reduces the potential for intermittent fish kills. o reduces source of contamination for Humber Marsh and the lake (drinking water). o improves public awareness.
8. Dog and Litter Control	NC	Basin-wide	o reduces FC loads in wet weather. o improves aesthetics.	o lessens public health risk. o enhances recreational enjoyment. o improves public awareness.
9. Sediment Control Programs	NC	Basin-wide	o reduces in-stream sediment concentrations. o reduces sediment load to lake.	o reduces stress on fishery. o provides impetus for fishery habitat improvement. o reduces accumulation of sediment, nutrients and toxic substances in Humber Marsh and lake.
10. Rural Controls	NC	Upper Watershed	o reduces FC counts in upper Humber River. o reduces loads of sediment, nutrients and toxic substances to lake.	o lessens public health risk. o reduces accumulation of sediment, nutrients and toxic substances in Humber Marsh and the lake.
11. Disinfection	$0.2 mill	Pilot Project (Emery Creek)	o reduces major FC source in upper urban basin during dry weather. o provides test facility for optimizing dry weather disinfection technology. o provides test facility for treatment of retained stormwater.	o decreases dry weather FC counts between Emery Cr. and Black Cr. o lessens public health risk. o allows detailed evaluation of the capabilities and flexibility of dry weather disinfection. o allows evaluation of the feasibility of disinfecting wet weather flow.

* Present value in millions of 1985 dollars, NC - Not Costed

Table 9.1 (cont'd)

	Cost*	Scale	Effects	Benefits
12. Stormwater Ponds (existing areas)	$1.3 mill	Pilot Project (Emery Creek)	o reduces metal loads from a major industrial catchment. o provides protection against spills. o provides test facility for evaluating pond effectiveness in terms of fishery enhancement. o provides test facility for optimization of pond design for load reduction.	o reduces PWQO violations locally. o reduces potential for acute toxic impacts on fishery. o provides impetus for parallel fishery habitat project. o allows improved quantification of the fisheries benefits of stormwater control. o allows evaluation of watershed specific load reductions for metals, nutrients and sediment.
13. Stormwater Ponds	NC	Pilot Projects (test sites to be determined)	o controls pollutant loads from new developments. o provides test facilities for evaluating pond effectiveness in developing areas.	o reduce future degradation of the watercourse. o reduce future contaminant loads to the lake. o allows evaluation of fisheries impacts in less stressed environments. o allows evaluation of load reductions in developing areas.
14. Enhanced Water Quality Monitoring	NC		o provides system data for watershed. o provides specific data on the impacts of combined water quality and habitat improvement.	o allows evaluation of overall Phase 1 effectiveness. o allows evaluation of specific fishery improvements possible.

*Present Value

Table 9.2 : Humber River Management Plan - Phase 2

Option	Basis for Decision to Proceed	Scale	Cost *	Benefits
Disinfection (low flow)	o lack of success in tracing and eliminating bacterial sources o demonstrated effectiveness at Emery Creek facility	Black Cr. and other tributaries and priority outfall clusters	$0.2 million per facility	o reduction of dry weather FC counts o lessen public health risk
Disinfection (retained stormwater)	o demonstrated effectiveness of stormwater disinfection at Emery Creek o decision to proceed with stormwater pond controls throughout urban Humber	all feasible pond sites	$0.2 million per facility	o reduction of wet weather FC counts o lessen public health risk
Industrial Ponds (existing areas)	o demonstrated effectiveness of Emery Creek facility o demonstrated impacts on in-stream fishery in vicinity of Emery Creek site	all feasible pond sites serving primarily industrial areas	$1500/ha served + land cost (estimated cost: $3.8 mill + land)	o improved fishery o major reduction in loads to lake o major reduction in PWQO violations o spill control o aesthetic improvements
Residential Ponds (existing areas)	o as above o completion of industrial pond implementation program	all feasible pond sites serving primarily residential areas	$1500/ha served + land cost (estimated cost: $16.2 mill + land)	o as above
Ponds (new developments)	o demonstrated effectiveness of proposed test facilities	all new developments	NC	o as above o prevent future degradation of fishery

* Present value in 1985 dollars, NC - Not Costed

9.1 RECOMMENDATIONS

The proposed management plan for the Humber River may be represented as a series of recommendations relating to structural and non-structural control options. Broad policy-level recommendations are stated, followed by more specific and detailed sub-recommendations. It is recognized that improvement of water quality in the Humber River cannot be accomplished through a one-time "fix and forget" strategy. Many of the recommendations therefore suggest ongoing control, phased implementation, and additional studies. Phasing is recommended for each sub-recommendation.

The primary emphasis of the management plan will be directed towards existing urban sources. In particular, measures which will reduce the buildup or delivery of contaminants are important. The following recommendations are therefore provided to encourage a major reduction in the contribution of contaminants from the urban portion of the Humber River basin.

1. <u>It is recommended that a program of enhanced catchbasin cleaning be implemented throughout the urban watershed</u>, specifically that:

<u>Phase 1</u>

a) the frequency of catchbasin cleaning be increased to twice per year in all urban areas tributary to the Humber River;

b) the supernatant collected during catchbasin cleaning be discharged to sanitary sewers for treatment;

c) disposal sites for catchbasin spoils be examined and if necessary re-designed to prevent runoff and leaching of contaminants to watercourses.

It is noteworthy that for c) above, disposal sites for catchbasin spoils must be certified under the Environmental Protection Act.

2. <u>It is recommended that combined sewer overflows to Black Creek be eliminated to a practical extent</u>, specifically that:

<u>Phase 1</u>

Combined sewer overflow tanks be constructed on Black Creek to reduce the frequency of overflow to an average of once per year. Stored overflows are to be routed to the WPCP for treatment once dry weather flow conditions are resumed.

3. <u>It is recommended that an effective program be established to reduce dry weather bacteria counts.</u> Currently a program involving tracing and eliminating sources is underway.

The impacts of this initiative have not yet been established. Other methods of reducing in-stream bacteria counts during dry weather include interception of dry weather flow for treatment at the WPCP or in-stream disinfection. It is therefore recommended that:

<u>Phase 1</u>

a) an assessment be made of the effectiveness of the program to trace and eliminate sanitary sewage cross-connections to storm sewers in reducing dry weather bacteria counts;

b) the feasibility of collecting dry weather flow and diverting it to the WPCP for treatment be determined for priority outfalls;

c) an ultraviolet disinfection unit be constructed to provide treatment of dry weather flows on Emery Creek as part of a pilot project.

If the results of a) and b) are less than fully effective, then it is recommended that a general program of disinfection be considered, specifically that:

Phase 2

d) the use of ultraviolet disinfection be considered for the treatment of dry weather flows at other sites such as the retention facilities which may be constructed in the future, or at existing sites such as the Claireville reservoir.

It is noteworthy that a decision to proceed with dry weather disinfection should not be construed as a reason for not pursuing the tracing and disconnection of illegal sanitary sewer connections to storm sewers. Sanitary sewage discharges to any open watercourse are unacceptable and all possible efforts should be made to mitigate known problems in this regard.

4. It is recommended that programs aimed at the prevention and reduction of continuous sources of dry weather contamination be continued and expanded, specifically that:

Phase 1

a) efforts continue to ensure the prevention of illegal connections to storm sewers. This may require an increase in the staff available to provide plumbing inspections;

b) efforts should continue to ensure the prevention of illegal discharges to sanitary sewers;

c) existing sewer use bylaws be reviewed with a view towards amending them to provide stricter standards for the permissible discharge of contaminants to storm sewers.

With regard to c) above, some guidance may be available from the revised Model Sewer Use Bylaw which will be available in draft form in the near future. The revised Model Bylaw will suggest additional contaminants which should be controlled, beyond those currently contained in the present bylaw.

The permissible level of contaminants in storm sewer discharge should be dependent on the assimilative capacity and quality of the receiving stream. Black Creek and other urban tributaries are urban streams in which the PWQO are regularly exceeded. As such, stricter controls can be justified in terms of dry weather discharge to storm sewers located on these streams. Existing bylaws should therefore be reviewed to determine the feasibility of providing standards for the discharge of contaminants which are closer to the PWQO. The exact level acceptable for each parameter should be established jointly by MOE and the municipalities.

5. It is recommended that stormwater retention facilities be constructed to provide control of pollution from catchments receiving significant runoff from industrial land uses. This recommendation is vital to the success of a management strategy. It is recognized that there will be difficulties in its implementation. It is therefore recommended that a phased approach be adopted as below:

Phase 1

a) a stormwater retention facility should be constructed on Emery Creek near the confluence with the Humber River to provide control of pollution from the predominantly industrial catchment to the north. The

Emery Creek facility should be operated as a pilot project to demonstrate the effectiveness of retention facilities in reducing stormwater pollution. Test programs such as the disinfection of stored runoff, using ultraviolet light, should be considered;

b) stormwater retention facilities should be constructed at test sites within new industrial areas. The facilities should be operated as pilot areas as described in a);

c) the design of these facilities should recognize that the purpose would be for both water quality and quantity control and should include a specified maintenance program. Detailed design and operational guidelines for quantity and quality should be developed for retention ponds including additional treatment facilities such as disinfection.

Phase 2

d) additional retention facilities should be constructed within existing urban areas, subject to positive results in a) above, at feasible sites;

e) stormwater retention facilities should be constructed within new industrial developments to provide control of pollution, subject to positive results in b) above.

It is anticipated that several years will elapse between the implementation of a) and d) above. The various source controls (e.g. Recommendations 1, 3, and 4) which are to form a continuing part of the ongoing management strategy, will be particularly important during this intervening period. It will be useful to monitor the impacts of these latter recommendations in order to

determine whether they can have sufficient impact to reduce the need for ponds.

6. <u>It is recommended that stormwater retention facilities be constructed to control stormwater pollution from residential and commercial catchments</u>, specifically that:

<u>Phase 2</u>

a) stormwater retention facilities should be constucted within existing residential and commercial areas, subject to positive results in 5a), at feasible sites;

b) stormwater retention facilities should be constructed within new residential and commercial developments to provide control of pollution, subject to positive results in 5b);

c) design and operational guidelines should be developed as specified in 5c).

It is recognized that a program involving the construction of residential ponds in existing areas may meet with resistance. The program should only be initiated after a substantial start has been made with ponds in industrial catchments. Residential areas contribute significantly to pollution of the Humber River however, and the importance of this recommendation to the overall strategy should not be overlooked.

The preceeding recommendations, if implemented to their fullest possible extent will produce significant improvements in the water quality of the Humber River. Certain problems will persist however, because of continuous or intermittent dry weather contamination. In general, these latter problems must be resolved through regulatory measures. The following recommendation is therefore made.

7. <u>It is recommended that the program of identification and elimination of illicit dumping of liquid wastes in industrial and commercial catchments be expanded</u>, specifically that:

<u>Phase 1</u>

a) additional staff be provided to augment inspection of industrial and commerical establishments for pollution sources and to ensure regular surveillance of storm sewer outfalls from industrial areas and commercial establishments. The staff should be locally based so as to promote familiarity with industries and commercial establishments within a given catchment;

b) a data base be compiled to provide information on the industries and their products and by-products, on an outfall specific basis. In addition, information should be obtained on processes;

c) the educational program to increase industrial and commercial establishments awareness of the problems caused by illicit dumping or careless handling of contaminants be expanded and strengthened;

d) contingency, containment and cleanup plans be maintained to ensure rapid response and mitigation of accidental spills and intentional dumps of contaminants. Plans should be updated periodically to ensure they are suitable for handling the contaminants identified in b);

e) in the event of an incident, the information compiled in b) be used in conjunction with sampling and field investigations to determine the source of contamination so that appropriate action may be taken.

It is noteworthy that applicable regulations for this recommendation are the Sewer Use Bylaw, the Spills Bill and Regulation 309. Information on liquid industrial wastes and hazardous wastes produced will be available under Regulation 309 and can be broken down into areas such as MOE district offices and municipalities. It will be difficult to extract the data on a sewershed basis, thus other sources of information should be examined.

Recommendations 1 to 7 seek to mitigate specific sources of contamination through the most technologically effective means. It should be recognized, however, that certain contaminants cannot be effectively controlled by end of pipe or source controls. For this reason it is necessary to formulate a series of good management practices, which, if enthusiastically adopted by private, public and institutional sectors, could reduce the magnitude of contaminant generation. These good management recommendations would be applicable to all urban catchments and should be applied as broad programs. Their importance is magnified however, in catchments where technological controls cannot be feasibly implemented. In such cases the good management recommendations presented below represent the only means of curtailing urban pollution.

8. <u>It is recommended that educational programs be implemented to promote improved handling and disposal of hazardous contaminants,</u> specifically that:

<u>Phase 1</u>

programs be implemented to inform and educate the public of the existence, potential hazards, and safe handling of household hazardous wastes. A guideline aimed at assisting municipalities in implementing such programs will be availible in the near future from MOE.

9. It is recommended that additional programs be developed to aid in the reduction of contamination to the urban watershed, specifically that:

Phase 1

a) bylaws and education programs to reduce contamination by dog feces be strengthened and that enforcement be augmented. This measure will lead to additional benefits in terms of aesthetics;

b) litter control programs be pursued in order to promote greater public awareness of an individual's responsibility in reducing pollution;

c) snow disposal facilities be monitored to ensure that they are meeting MOE snow disposal guidelines and are not contributing to water quality degradation;

d) the provincial and federal governments continue to pursue programs aimed at reducing air emissions, in order to reduce wet and dry deposition of contaminants.

In addition to water quality, flooding of basements is also a problem where combined sewers exist in the City of York.

10) It is recommended that basement flooding be reduced, specifically that:

Phase 1

a) the program of sewer separation currently underway in the City of York be reconsidered because of its high cost, level of protection, and the feasibility of other alternatives for reducing flooding and overflows;

(b) basement flooding in the City of York be reduced through the use of local storm water storage tanks to provide protection up to the 1 in 10 year return period storm.

Although the primary emphasis of the management plan will be on controls relating to existing development within Metro, there will be cases where controls can be implemented as part of new development or redevelopment. In general there is greater flexibility available when considering the extent and siting of pollution control facilities in new developments, than in retro-fit situations. A new development or redevelopment project should be controlled to at least the same extent as existing development. In addition, however, efforts should be expanded to specifically address sediment delivery, both at the development site and in-stream, as below:

11. <u>It is recommended that programs aimed at reducing sediment delivery to streams be continued and expanded where feasible,</u> specifically that:

<u>Phase 1</u>

a) programs requiring control of erosion and sediment transport/delivery from construction sites be continued, and that proponents of new developments or redevelopment projects be required to prepare sediment and erosion control plans to prevent long term impacts, as part of the subdivision review and approval process;

b) modern stormwater management practices relating to quantity control, be required in all new developments and redevelopment projects to reduce runoff rates;

c) programs to reduce erosion of streambanks, valley walls and areas adjacent to watercourses be continued;

d) programs to reduce of sediment delivery from overland sources be encouraged. The programs include the greater use of porous paving, open ditches, or buffer strips, particularly on unpaved storage sites (see Appendix A).

Limitations on a) and b) above, will have to be recognized for redevelopments that have a limited amount of space available for control projects; for example, redevelopment of a single site in a highly urbanized area.

The upper portions of the Humber River basin are responsible for a significant contribution of contaminants to the lower reaches and the lake. Although the unit loads produced by the rural areas are small in comparison to the urban loads, the size of the area contributing is such that the loads generated cannot be ignored. Actions as indicated below will therefore form an important part of the management plan.

12. <u>It is recommended that action be taken to ensure a reduction in contamination from sources in the upper Humber,</u> specifically that:

<u>Phase 1</u>

a) the upper Humber should be added to the enhanced Ontario Soil Conservation and Erosion Prevention Assistance Program (OSCEPAP);

b) livestock access to the river be reduced through streambank fencing, armoured walkways and the provision of alternate watering facilities;

c) further studies be undertaken to determine the water quality impacts of diffuse urban sources and point sources such as the Kleinburg WPCP and that if warranted, improved treatment be provided as part of any expansion program;

d) studies be undertaken to determine methods of improving the water quality in the Claireville Reservoir;

e) that modern agricultural practices be encouraged in order to reduce the delivery of sediments, nutrients and pesticides to the river;

f) manure contamination of the river be reduced through improved holding facilities, proper siting of storage areas and changes in farm operation practices;

g) efforts continue to ensure that old landfills are located and leachate tested to ensure that they do not contribute to water quality degradation of the Humber River;

h) programs aimed at tracing and disconnecting improper or illegal connections to field tile drains be initiated;

i) programs to monitor, locate and mitigate malfunctioning or poorly designed septic tank systems be continued.

The recommendations outlined above will require the assistance of the Ontario Ministry of Agriculture and Food, and the Ministry of Natural Resources.

It will be important to continue to monitor the Humber River in order to note the progress of the management strategy. Continued data collection is warranted in order to allow an evaluation of the performance of the pilot projects, to better define the contaminant inputs to Humber Bay and to identify any new problems. The following recommendation is therefore made.

13. It is recommended that water quality sampling of the Humber River be continued in order to monitor the impacts of the controls on in-stream water quality. An appropriate sampling program should be developed in order to provide information on the impacts of the implementation of control options throughout the progress of the management strategy.

An important aspect of the management plan involves improvement of water quality from a fisheries perspective. Additional fisheries initiatives are required in order to properly evaluate the beneficial impacts on the fishery and to determine if the Humber River fishery can be improved. The following recommendation is therefore made.

14. It is recommended that the Ministry of Natural Resources implement programs aimed at the enhancement of fisheries in the Humber River, specifically that;

Phase 1

a) a pilot scale fisheries program be initiated in order to determine the benefits of a combined water quality, habitat improvement, and fisheries management program.

Phase 2

b) that additional habitat improvement and fisheries management programs be considered for the Humber River, subject to an improvement in the Humber River as a result of the management plan, and positive results in a) above.

10. IMPLEMENTATION CONSIDERATIONS

One of the evaluation criteria presented in chapter 4 was implementability. Discussion of the implementation of control options to this point has focused on technical feasibility as well as public and agency acceptance. The aim of this chapter is to go beyond this and examine funding sources, approval mechanisms and to identify possible implementors.

10.1 FUNDING SOURCES

Several of the recommendations detailed in chapter 9 involve an enhancement of existing programs, and as such have some form of funding in place. The implementation of some of the enhanced programs will thus require only an internal budgetary approval for municipal funds (e.g. enhanced catchbasin cleaning). For other programs changes at the provincial level will also be required. For example, the Ontario Ministry of Agriculture and Food (OMAF) currently administers the Ontario Soil Conservation and Environmental Protection Assistance Program (OSCEPAP) which applies to watersheds throughout the province. The MOE has enhanced the OSCEPAP by increasing subsidies for many control practices, and what is required is that the upper Humber be added to the enhanced program.

Some recommendations have funding in place but will require a redirection of the funds. The existing combined sewer separation program is currently funded through grants from the Province and Metro (and, in the past, from the Federal Government) in addition to local municipalities. The recommendations with respect to combined sewer overflow control and basement flood protection replace the sewer separation programs with lower cost methods. However, the funding formula would have to be modified for the funds originally slated for combined sewer separation to be redirected to these programs.

Some recommendations cover programs which do not currently exist in Metro area municipalities and this would require that a program be developed. This includes construction and operation of stormwater quality control ponds and development of a hazardous contaminants handling program. For the stormwater ponds, the MOE has been identified as the agency to fund and operate the pilot project. Funding for full scale implementation would require participation by all levels of government.

10.2 APPROVAL MECHANISMS

Most projects would be subject to some approval mechanism (Table 10.1). At the minimum, internal and budgetary approval for use of municipal funds would have to be obtained. Sewage works would be subject to approval under the Ontario Water Resources Act (OWRA). Approval under the OWRA may require that public hearings be held. The holding of these hearings is at the discretion of the regional director of the MOE.

Construction of ponds and other structures in the flood plain would be subject to approval of the Ministry of Natural Resources under the Lakes and Rivers Improvement Act, and Construction and Fill Regulations under the Conservation Authorities Act.

Many of the proposals may be subject to Environmental Assessment (EA). Sewage works are currently exempt from assessment unless they are classed as new sewage treatment works. A proposed Municipal Class EA currently being approved by the MOE will in future cover all municipal sewage and water works. Implementation of these works should recognize this fact. A proposed Class EA for Conservation Authority projects is also currently under review by MOE and will replace the current exemption under the Environmental Assessment Act.

A few recommendations can be implemented immediately. Others are dependent on implementation of recommendations in a staged

TABLE 10.1 : APPROVAL MECHANISMS

Agency	Legislation	Jurisdiction/Responsibility
Municipality	Municipal Act/ Regional Act	- construction and operation of drainage and stormwater works - drainage bylaws, codes, criteria - subdivision agreements with developers
Conservation Authority	Conservation Authorities Act	- flood control, water management, conservation
	Fill and Construction Regulations	- approval of construction activities within the flood plain
Ministry of Municipal Affairs and Housing	Planning Act	- allows Ministries/Agencies to comment on large developments and subdivision proposals
Ministry of Natural Resources	Lakes and Rivers Improvement Act	- approval of works in lakes and water courses (alterations and diversions)
	Beds of Navigable Waters Act	- crown ownership of beds of navigable waters
	Fisheries Act (Canada)	- fisheries, fish habitat
	Conservation Authorities Act	- administration; technical and financial assistance to CA's.
Ministry of the Environment	Ontario Water Resources Act	- approval of sewage works; public hearings may be called - water quality
	Environmental Protection Act	- activities which might injure the environment
	Environmental Assessment Act (proposed Munucipal Class EA)	- sewage works currently exempt, unless new sewage treatment works - proposed Municipal Class EA will cover municipal sewage and water works - as well, proposed Class EA for Conservation Authority projects will replace current exemption
Ministry of Transportation and Communications	Public Transportation and Highway Improvement Act	- subsidies for drainage works for urban roads and streets, including combined sewer separation
Ministry of Agriculture and Food	Drainage Act	- subsidies for work on drains to serve agricultural drainage requirements; applicable occasionally in urban setting

sequence. In order to ensure continued effort, to make decisions where required on staging, and to evaluate progress on recommendations, a co-ordination body is necessary.

Table 10.2 presents a synopsis of implementation considerations for each of the technical recommendations given in chapter 9. Summary findings and conclusions are drawn as follows:

- o Most recommendations would be implemented by local municipalities, possibly jointly with Metro and higher levels of government.

- o Studies and activities in the upper Humber would be implemented by a variety of agencies including the Ontario Ministry of Agriculture and Food and the Conservation Authority. Erosion control programs and controls on new development would be implemented through the Planning Act by municipalities, with the MTRCA as the primary technical reviewer.

- o Water quality monitoring would be implemented by the Ministry of the Environment, possibly with the assistance of MTRCA, and Metro.

- o Some recommendations involve augmentation to existing programs and thus require no major alterations to administrative procedures. Example:

  - enhanced catchbasin cleaning
  - reduction of combined sewer overflows
  - basement flood reduction
  - application of existing bylaws

TABLE 10.2 : IMPLEMENTATION CONSIDERATIONS

Recommendations	Implement. Program		Possible Implementor					Possible Funding					Approval Mechanism	Phase	Comments
	Existing	Needs Dev.	Local Mun.	Metro	Cons. Author.	Prov.	Fed.	Local Mun.	Metro	Cons. Author.	Prov.	Fed.			
1. Enhanced catchbasin cleaning	X		X	X				X	X		X		Municipal budgeting	I	Can be implemented immediately
2. Reduction of CSO (installation operation & maintenance of storage tanks and WPCP treatment)	X	X	X					X	X		X		LRIA(possibly OWRA, EA) Municipal budgeting	I	Requires funding formula change at metro and province. MTC subsidize currently.
3. DWF bacteria reduction - (a) trace/Elim	X		X					X			X		Existing by-laws	I	Underway
- (b) collection	X	X	X	X				X	X		X		LRIA (possibly OWRA/EA)	II	Depends on success of 3a
- (c) disinfection - pilot project		X				X	X				X	X	OWRA (possibly LRIA/EA)	I	Can be implemented immediately
- full scale implementation		X	X	X				X	X		X		"	II	Depends on success of 3a and pilot project
4. Curtail legal and illicit continuous discharges (prevent, eliminate & review bylaws)	X	X	X	X		X	X	X	X		X	X	Modify bylaw	I	Partially Ongoing. Initiate expansion immediately
5. Industrial ponds (installation, operation & maintenance) - pilot project		X				X					X		LRIA/OWRA/EA	I	Can be implemented immediately
- full scale implementation		X	X					X	X		X		" "	II	Depends on success of pilot project
6. Residential ponds (" " ")		X	X	X				X	X		X		LRIA/OWRA/EA	II	Depends on success of rec 4 pilot project
7. Prevent intermittent dumping (education, identification, data base, contingency and elimination)	X	X	X	X		X	X	X	X		X	X	Existing bylaw	I	Can be implemented immediately under existing programs
8. HC handling and disposal (develop and implement programs)	X	X	X	X	X	X	X	X	X		X	X		I	Partially Ongoing. Initiate expansion immediately MOE has model programs
9. Dog bylaws, litter control, snow disposal and emission controls (education/enforcement enhancement)	X	X	X	X	X	X	X	X	X	X	X	X	Existing Programs	I	Partially Ongoing. Initiate expansion immediately
10. Basement flooding reduction (use of storage tanks Vs sewer separation	X		X					X	X		X		OWRA	I	Can be implemented immediately. Requires funding formula changes similar to rec 2
11. Enhanced erosion control (redevelopment/new development, modern stormwater Management Practices)	X	X	X		X	X		X	X	X	X		Planning Act, LRIA	I	Ongoing, enhancement depends on province guideline development
12. Enhanced upper Humber controls	X	X	X York and Peel Regions		X	X		X York and Peel Regions		X	X		Existing programs and studies	I	Possible future federal involvement on phosphorus reductions. OMAF OSCEPAP program can be used.
13. Enhanced water quality monitoring	X		X	X	X	X		X	X	X	X	X	None required	I	Can be implemented immediately
14. Enhanced fishery habitat - pilot project	X	X				X					X	X		I	MNR fisheries management plan
- full scale implementation	X	X			X	X				X	X			II	Depends on success of pilot project

MOE = Ministry of the Environment
MNR = Ministry of Natural Resources
MTC = Ministry of Transportation and Communication

LRIA = Lakes and Rivers Improvement Act
OMAF OSCEPAP = Ontario Soil Conservation and Environmental Protection Assistance Program of the Ontario Ministry of Agriculture and Food.
OWRA = Ontario Water Resources Act
EA = Environmental Assessment

10.3 IMPLEMENTATION RECOMMENDATIONS

Based on the analysis presented above, the following implementation recommendations are made:

1. It is recommended that a committee be established to co-ordinate the activities of the existing agencies in implementing the water quality management plan. The committee would consist of members from implementing agencies and basin municipalities. The committee would deal with the scheduling and implementation of recommended control options, modify recommendations as required, and make recommendations regarding implementation of phase 2. The committee would report on progress to the Minister of Environment, the Chairman of Metropolitan Toronto, the Mayors of the local Municipalities and the Chairman of the MTRCA.

2. It is recommended that all agencies proceed with the implementation of recommendations as outlined in Chapter 9. The components of the management plan should be implemented with the following agencies taking the lead role (recommendation number given in brackets):

Ministry of the Environment	Dry Weather Flow Bacteria Reduction (disinfection - pilot project) (3 c), Industrial Ponds (pilot project) (5), Hazardous Contaminant Handling and Disposal (8), Enhanced Water Quality Monitoring (13)
Ministry of Natural Resources	Enhanced Fishery Habitat (14)

Metropolitan Toronto and Region Conservation Authority	Enhanced Erosion Control (11), Enhanced Upper Humber Controls (12)
Metropolitan Toronto	Prevent intermittent dumping (7), Curtail legal and illicit continuous discharges (4)
Local Municipalities	Enhanced Catchbasin Cleaning (1), Reduction of CSO (2), Dry Weather Flow Bacteria Reduction (trace/elim, collection, disinfection-full scale) (3 a,b,c), Stormwater Ponds (full scale) (5,6), Additional progress to reduce contamination of the urban watershed (9), Basement Flooding Reduction (10).

It is recommended that local municipalities develop and implement pollution control programs with guidance and technical assistance from Metro, MOE and the CA.

A reasonable time frame should also be applied, with all phase I activities in place within 3 years, to be followed by phase II, 2 years later.

3. It is recommended that the Municipality of Metropolitan Toronto change its policy to include the treatment of stored combined sewage (sanitary and storm runoff), and change the funding formula to allow and encourage alternatives to combined sewer separation.

4. It is recommended that MOE and MTC consider changes in funding of combined sewer separation programs to include funding of combined sewer overflow controls and basement flood control works other than sewer separation.

5. It is recommended that MOE act as the lead agency in approaching the Federal Government and other levels of government for additional funding for programs to be implemented by local municipalities and the Conservation Authority.

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